2

MICROPLANKTON FROM AUSTRALIAN AND NEW GUINEA UPPER MESOZOIC SEDIMENTS

By Isabel C. Cookson* and A. Eisenack†

[Read 11 July 1957]

Abstract

The distribution of 75 species of fossil microplankton from Australian and New Guinea Upper Jurassic and Cretaceous deposits has been recorded and 12 new genera and 54 new species have been described. Some of the types have been identified with European species.

Upper Jurassic, Aptian, Albian, Cenomanian and Campanian microplankton assemblages have been distinguished.

Introduction

Three papers dealing partly (Cookson, 1953) or wholly (Deflandre and Cookson, 1955, and Cookson, 1956) with Australian fossil microplankton have already been published. The present and fourth contribution was to have been made in conjunction with Professor G. Deflandre of Paris, but pressure of work and other unforeseen circumstances rendered this impossible. Professor A. Eisenack then agreed to act as collaborator to assist with the taxonomic section of the paper.

This publication, unlike the earlier ones which dealt only with Tertiary and Cretaceous species, is concerned solely with Jurassic and Cretaceous types. Moreover, its scope has been enlarged to cover the Papuan region of New Guinea. The fossiliferous sediments comprising shales, siltstones, and calcarenites were chiefly supplied by West Australian Petroleum Pty. Ltd. (to be referred to hereafter as "Wapet") and by Island Exploration Co. Ltd. (to be referred to hereafter as "I.E.C.") from exploratory bores sunk respectively in the Exmouth Gulf and other areas of Western Australia and at Omati in Papua, New Guinea. Cretaceous samples provided by the Department of Geology, University of Queensland, the Queensland Geological Survey and the South Australian Department of Mines have also yielded species of microplankton that are both stratigraphically and morphologically interesting.

Some of these deposits have been reliably dated by means of ammonites, belemnites and foraminifera, the age of others is less certain. Some, for example the Gearle Siltstone of Western Australia, contain rich and varied microplankton assemblages, while in others, such as the Omati Well sample No. 30 (Table 1), one particular species predominates.

This work includes only a small proportion of the species present in the Mesozoic deposits examined. Many of these are new types, whilst those referable to European species have extended both the geographical and geological ranges of the particular forms.

For the isolation of the fossils the hydrofluoric acid—Schultz's solution—alkali treatment was adopted exclusively. The powdered and sieved rock was thoroughly boiled in hydrofluoric acid and allowed to stand over night, after which the residue

* Botany Department, University of Melbourne.
† University of Tübingen, Germany.

was macerated in Schultz's solution (concentrated HNO_3 + $KClO_3$) for at least 12 hours and, after several washings with water, cleared in 10% sodium hydroxide. The final residue was mounted in Safranin glycerine jelly.

Location and Age of Sediments

Western Australia:

All samples from Western Australia were supplied by Wapet. Many of these were taken from formations dated by palaeontological means. The age of the Jurassic Dingo Siltstone is based on the ammonite studies of Dr. W. J. Arkell and the pelecypod studies of Dr. L. R. Cox. The dating of the Cretaceous formations is

Fig. 1.

based on foraminiferal correlations by Dr. M. F. Glaessner, Miss I. Crespin and Mr. D. J. Belford. Details of these correlations are given by McWhae et al. (1957 ms.).

1. Canning Basin. Broome No. 3 Artesian bore at 1405-37 ft. Age: Upper Jurassic—Tithonian according to Brunnschweiler (1954), Oxfordian to Lower Kimeridgian according to Teichert (1940, 1947).

2. Carnarvon Basin.
   (a) Exmouth Gulf Area.
      i. Rough Range. Well No. 1 is located 22°25′ S., 114°5′ E.
         Learmonth Formation. Wapet's Well No. 1 at 4376-79 ft. Age: Upper Jurassic.
         Muderong Shale. Wapet's Well No. 8 at 3863-83 ft. Age: Lower Cretaceous (Aptian).
         Windalia Radiolarite. Wapet's Well No. 4 at 3532-50 ft. Age: Lower Cretaceous (Aptian) and Lower Albian.
         Gearle Siltstone (lower part). Wapet's Well No. 7 at 2360-75 ft. and Well No. 1 at 2000 ft and 2750 ft. Age: Lower Cretaceous (Albian).
         Gearle Siltstone (upper part). Wapet's Well No. 8 at 1530-48 ft. and Well No. 5 at 1570 ft. Age: Upper Cretaceous (Cenomanian to Lower Turonian).
         Korojon Calcarenite. Wapet's Well No. 4 at 1380-86 ft. Age: Upper Cretaceous (Campanian to Lower Maestrichtian).
      ii. Cape Range. Well No. 2 is located 22°6′ S., 114°E.
         Dingo Siltstone (middle portion). Wapet's Well No. 1 at 6365-83 ft. Age: Middle Jurassic (Lower Callovian).
         Dingo Siltstone (upper portion). Wapet's Well No. 2 at 6032-50 ft. Age: Upper Jurassic (? Oxfordian).
         Dingo Siltstone (upper portion). Well No. 1 at 3825-40 ft. and Well No. 2 at 3970-91 ft. and 4509-27 ft. Age: Upper Jurassic (? Middle or Lower Kimeridgian).
   (b) Salt Marsh Area.
      "Grierson Member" of Birdrong Formation. Wapet's Grierson Well No. 3 at 1390-1400 ft. Age: Lower Cretaceous (Upper Neocomian to Lower Aptian).
   (c) South-Western Area.
      Probably "Grierson Member", Birdrong Formation. Meadow Station Artesian Bore No. 9. Age: Lower Cretaceous (? Upper Neocomian or Lower Aptian).

3. Perth Basin.
   (a) Gingin area.
      i. Seismic shot hole B.1, 4 m. N. of Gingin at 230 ft. Age: Probably Lower Cretaceous (Albian). See stratigraphical conconclusions.
      ii. Seismic shot hole L.8 near Regan's Ford on Moore River at 240 ft. Age: Probably Lower Cretaceous (Albian). See stratigraphical conclusions.
      iii. Moora Bore at 86-170 ft. Age: Probably Lower Cretaceous. (Albian). See stratigraphical conclusions.

(b) Perth Metropolitan Area.
South Perth Formation.
i. Attadale Artesian bore at 809 and 899 ft. Age: Lower Cretaceous (? Aptian). See stratigraphical conclusions.
ii. Osborne Park (King Edward Street) bore at 265-95 ft. Age: Probably Lower Cretaceous (Albian). See stratigraphical conconclusions.
iii. Subiaco Artesian bore at 358 ft. Age: ? Upper Cretaceous (Cenomanian). See stratigraphical conclusions.

South Australia:

Cootabarlow, near Lake Frome. Grey siltstones from Bore No. 2 at 581 ft. and 1354 ft. Age: Lower Cretaceous (Albian and Aptian respectively). See stratigraphical conclusions.

New South Wales:

Onepah Station near Tibooburra. Soft fine-grained grey sandstone dug from a well at an unspecified depth. Age: Lower Cretaceous (Albian), H. O. Fletcher and E. J. Kenny in Deflandre and Cookson (1955, pp. 246, 294). See stratigraphical conclusions.

Queensland:

Roma Series, North Queensland. Calcareous deposit from a well on Batavia Downs Station. Cape York Peninsula at 45-49 ft., within 20 yds. of Main Road, 24 m. S. of Moreton's Telegraph station. Age: Lower Cretaceous (Aptian).

Styx River Series. Carbonaceous shale from Queensland Geological Survey's Bore 21 at 327 ft. sunk in the Tooloombah Creek area. Styx Coalfield about 80 m. N. of Rockhampton. Age: Lower Cretaceous (Albian), Walkom (1919).

New Guinea:

Omati River District, Western Papua. Carbonaceous deposits from I.E.C.'s Well No. 1. Age: Upper Jurassic to Lower Cretaceous (Albian-Aptian) as determined by I.E.C.

Era River District, Papua. Australasian Petroleum Company's Wana Well sample 451. Age: Upper Jurassic.

Description of Types

Class Dinoflagellata

Family Gymnodinidae

Genus **Gymnodinium** Stein

Gymnodinium crystallinum Defl.

(Pl. I, figs. 1, 2, 5)

Gymnodinium crystallinum Defl., 1938. *Trav. Stat. Zool. Wimereux,* 13; 165, Pl. V, fig. 1.

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 1 at 3825-40 ft. and Well No. 2 at 3970-91 ft.; Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.; Omati, Papua, I.E.C. Well

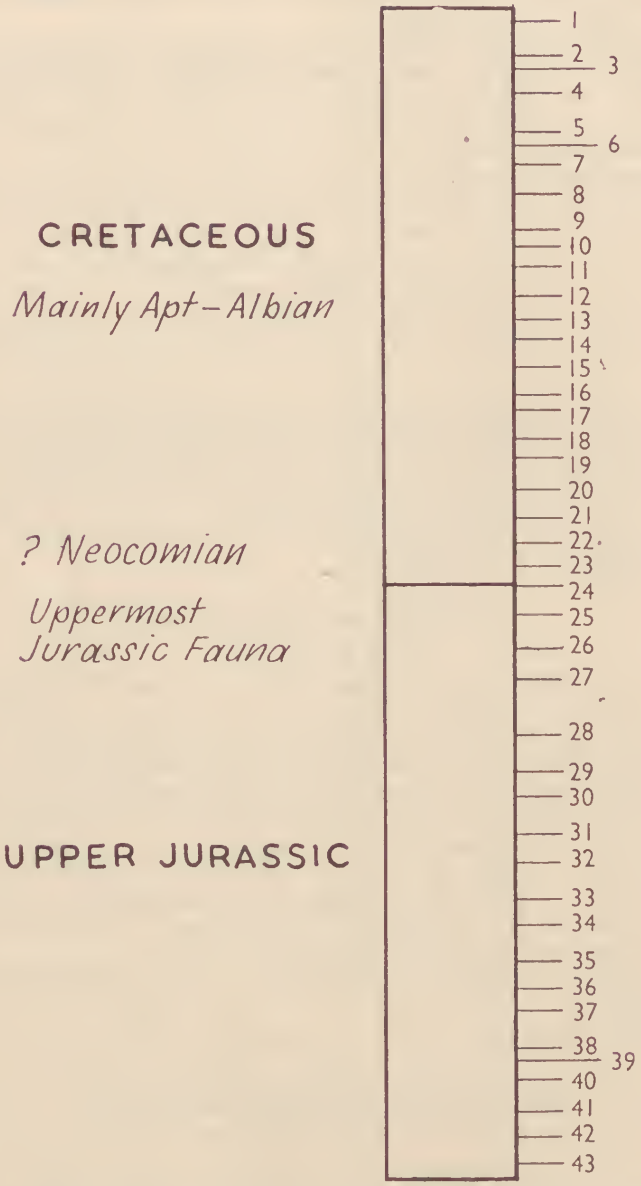


Fig. 2.—Diagram showing the Relative Stratigraphic Positions of Mesozoic Samples from Omati, Papua.

No. 1, Samples 24, 35 (Table 1). Middle Jurassic: Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1 at 6365-83 ft.

Description. Since many of the species of Mesozoic microplankton are known, as yet, from only a relatively small number of individuals, a wide degree of variation has been allowed throughout this work when referring southern forms to northern species, and this applies particularly to the present record of *Gymnodinium crystallinum* in the Australian area.

The example from Broome, W.A. (Pl. I, fig. 1), agrees exactly with the holotype from the French Oxfordian. The specimens obtained from the upper portion of the Dingo Siltstone (Cape Range), of which the form shown on Pl. I, fig. 2 is a representative, on the contrary, vary more or less considerably from it and eventually may prove to represent a distinct species. They are more elongated and considerably larger than the French specimens (142-166 μ long and 109-147 μ wide as against 65-92 μ x 58-85 μ) and have a distinct and very characteristic apical prominence.

The forms occurring in the middle portion of the Dingo Siltstone (Pl. I, fig. 5) are smaller (81-90 μ x 76-85 μ) and more comparable in size to the French examples. They appear to have been a much thicker and more substantial type than *Gymnodinium parvimarginatum* sp. nov. from the Broome bore which they approach in the width of the margin surrounding the capsule.

With few exceptions a large pylome has been present in the epitheca of all the Australian specimens of *G. crystallinum.*

Gymnodinium luridum Defl.

(Pl. I, figs. 3, 4)

Gymnodinium luridum Defl. *Trav. Stat. Zool. Wimereux,* 13; 166, Pl. V, fig. 4.

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W. A., Wapet's Cape Range Well No. 1 at 3825-90 ft. and Well No. 2 at 3970-91 ft. and 6032-60 ft.; Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.

Description. The Western Australian specimens agree closely with the original description of *Gymnodinium luridum* from the French Oxfordian and, like the French paratypes, are frequently broader than long.

Thin lines which suggest the limits of plates are evident on the dorsal surface of the hypotheca in some examples while the position of the longitudinal furrow is indicated, occasionally, by two narrow plates that run from the apex to the antapex of the ventral surface (Pl. I, fig. 3).

A large pylome (not noted in the French samples) has always been present on the epitheca.

Dimensions. Fig. 3—105 μ x 118 μ; Fig. 4—100 μ x 90 μ.

Gymnodinium parvimarginatum sp. nov.

(Pl. I, fig. 6; holotype)

Age and occurrence. Upper Jurassic: Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.

Description. Theca almost circular to broadly oval in outline, divided somewhat unequally by a straight and narrow transverse furrow into a rather shorter and occasionally slightly pointed epitheca and a longer rounded hypotheca. Inner capsule*

* Eisenack (1954) prefers the use of the term "capsule" to "cyst" as adopted by Deflandre (1938, p. 165).

not entirely filling the thin membrane but surrounded by a narrow margin *c.* 5 μ wide.

As in the Australian species of *G. crystallinum* and *G. luridum,* a relatively large pylome extends vertically from the transverse girdle almost to the apex of the epitheca.

Dimensions. Type 90 μ x 90 μ. Range 76-100 μ x 76-100 μ.

Comments. This species is distinguished by the almost circular outline, narrow margin (*c.* 5 μ), the width of which, in the Australian and New Guinea species of *G. crystallinum* is *c.* 5-15 μ and in *G. luridum c.* 7-10 μ, and its flatter form.

Gymnodinium attadalense sp. nov.

(Pl. I, fig. 7; holotype)

Age and occurrence. Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Bore at 809 ft.

Description. The test has a rather squarish outline with almost straight to convex sides and is divided unequally by a shallow transverse girdle into a slightly shorter and broader epitheca and a longer and somewhat pointed hypotheca.

The capsule follows the outline of the test but does not fill its cavity, a margin of about 11 μ being left around it. In the type the antapex of the capsule seems to be open, as does the membrane of the test directly opposite to it. However, this feature has not been evident in the three other examples of *G. attadalense* in the present collection. The outer membrane and membrane of the capsule are very faintly granular to smooth. A large pylome is developed in the epitheca.

Dimensions. Type 81 μ x 81 μ, capsule 59 μ x 59 μ.

Comments. G. attadalense is of the same general type as the Jurassic species *G. crystallinum, G. luridum* and *G. parvimarginatum,* but differs from all in the shape of the test.

These four species, in having flattened shells with thin margins, central capsules and conspicuous pylomes are distinct from such true fossil *Gymnodinia* as *Gymnodinium cretaceum* Defl., *G. heterecostatum* Defl. and *G. nelsonense* Cookson. It seems probable, therefore, that eventually they will be removed from the genus *Gymnodinium.* See Appendix 1.

Gymnodinium westralium sp. nov.

(Pl. I, fig. 9; holotype)

Gymnodinium cf. *heterocostatum* Defl. and Cookson 1955. *Aust. J. Mar. Freshw. Res.,* 6; 248, Pl. I, fig. 7.

Age and occurrence. Upper Cretaceous (Campanian and Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1350-88 ft. Upper Cretaceous (? Senonian Teichert 1947): Molecap Greensand, Gingin, W.A. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 8 at 1530-48 ft. and Well No. 5 at 1570 ft.

Description. Shell biconical, epitheca and hypotheca approximately the same size, the hypotheca being the more rounded of the two, separated by a narrow and apparently shallow transverse furrow; a longitudinal furrow is not apparent.

The shell membrane is ornamented with numerous longitudinal ridges that converge from the furrow to the apex and antapex respectively. In the specimens from the Gearle Siltstone the membrane between the ridges is smooth, in those

from the Korojon Calcarenite it has been regularly and longitudinally punctate. However, more examples will be needed to determine whether this feature is of primary or secondary origin.

Dimensions. Type 47 μ x 28 μ, other specimens 38 μ x 25 μ and 71 μ x 38 μ. Examples from Molecap Greensand 58-61 μ x 48-54 μ.

Comments. In shape, *G. westralian* resembles *G. cretaceum* Defl. from the French Upper Cretaceous (Senonian), but differs from this species in its larger size and narrower furrow. The two specimens from Gingin, doubtfully compared with *G. heterocostatum* Defl. by Deflandre and Cookson 1955, agree with *G. westralium* in shape, approximate size, and in having ridges of one size only.

Gymnodinium nelsonense Cookson

(Pl. I, fig. 8)

Gymnodinium nelsonense Cookson 1956. *Aust. J. Mar. Fresh. Res.*, 7; 183, Pl. I, fig. 10.

Age and occurrence. Upper Cretaceous (Campanian and Lower Maestrichtian) : Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, at 1350-88 ft.

Description. Two examples from the Korojon Calcarenite are referable to *G. nelsonense* originally described from the Upper Cretaceous portion of the Nelson Bore, Victoria. In the figured specimens, longitudinal ridges as well as folds are suggested.

Family Deflandreidae

Genus **Deflandrea** Eisenack

Deflandrea cincta sp. nov.

(Pl. IV, figs. 1-3; holotype, fig. 3)

Age and occurrence. Lower Cretaceous (Upper Neocomian or Lower Aptian) : Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore No. 9.

Description. Theca elongated, clearly separated into an epitheca and hypotheca by a strongly marked transverse girdle, a short longitudinal furrow is situated on the ventral surface of the hypotheca. The epitheca is convex laterally and narrows rather abruptly towards a short terminal truncated horn with a small central projection. The hypotheca is slightly narrower than the epitheca and posteriorly is prolonged on one side into a short, broad, sharply-pointed horn and on the other into a broadly conical expansion. The external membrane is somewhat coarsely granular.

The capsule is smooth, broadly oval, and usually extends laterally to the outer membrane.

Dimensions. Type—theca 88 μ x 52 μ; capsule 55 μ x 40 μ. Range—theca 81-118 μ x 52-66 μ; capsule 52-66 μ x 45-57 μ.

Comments. Deflandrea cincta although differing from the genotype *D. phosphoritica* Eis. and other species in having a prominent transverse girdle, is, by its shape, absence of plates and in the presence of an internal capsule, clearly a member of the genus *Deflandrea*. The development of both transverse and longitudinal furrows completely confirms Eisenack's reference (1938) of *D. phosphoritica* to the Dinoflagellata, although such features are not represented in that species. *D. cincta* is the dominant type in the microplankton assemblage of the Meadow Bore deposit.

Deflandrea acuminata sp. nov.

(Pl. IV, figs. 5-8; holotype, fig. 5)

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (Upper), W.A., Wapet's Rough Range Well No. 5 at 1570 ft. and Wapet's Rough Range Well No. 8 at 1530-48 ft. ? Upper Cretaceous (Cenomanian): Subiaco, W.A., Water Bore at 358 ft.

Description. Theca broadly oval with convex sides or almost spherical, apex acuminate, antapex obliquely truncate, prolonged on one side into a small pointed horn. A transverse girdle is perceptible at the lateral margins of the theca.

The capsule, which is always separated from the membrane of the theca by a relatively wide space is approximately spherical, and slightly pointed on the side directed towards the apex of the theca.

Both the internal and external membranes are smooth. A rounded or polygonal pylome is present above the apex of the capsule.

Dimensions. Type—theca 85 μ x 62 μ; capsule 48 μ x 48 μ. Range—theca 66-99 μ x 52-62 μ; capsule 38-47 μ x 38-47 μ.

Deflandrea pellucida sp. nov.

(Pl. IV, fig. 9)

Deflandrea bakeri f. *pellucida* Defl. and Cookson 1955. *Aust. J. Mar. Freshw. Res.*, 6; 251, Pl. IV, fig. 3 (holotype).

Age and occurrence. Paleocene to Lower Eocene: Nelson Bore, Vic., at 3874 ft. (Holotype); Pebble Point Formation, Vic. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-88 ft.

Description. Theca elongate oval with convex sides that narrow anteriorly towards an acuminate apex and posteriorly towards an obliquely truncate or slightly concave antapex. A transverse girdle is either faintly indicated or absent, a somewhat polygonal aperture is present in the anterior portion of the epitheca.

The capsule, which is broader than long and flattened in the antero-posterior plane, invariably extends laterally to the outer membrane. The membrane of the theca is finely granular, that of the capsule is smooth.

Dimensions. Type—theca 118 μ x 77 μ; capsule 67 μ x 74 μ. Western Australian examples—theca 109-128 μ x 76-81 μ; capsule 57-66 μ x 71-78 μ.

Comments. The organism here raised to specific rank, was originally described as a form of *Deflandrea bakeri* Defl. and Cookson, a Victorian Lower Tertiary species. Recently specimens identical in every way with *D. bakeri* forma *pellucida* were isolated from a sample of the Korojon Calcarenite (Campanian to Lower Maestrichtian) in NW. Western Australia. The constancy of their agreement with the Victorian examples when taken in conjunction with their wide geographical and geological separation, suggests specific rather than varietal rank for this type. Moreover *D. bakeri* has a more elongate form than *D. pellucida*, a more coarsely sculptured theca, and the internal capsule does not extend to the lateral margins. *D. bakeri* has not as yet been found in deposits of Cretaceous age.

Deflandrea korojonensis sp. nov.

(Pl. IV, figs. 10, 11; holotype, fig. 10)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, Wapet's Rough Range Well No. 4 at 1380-86 ft.

Description. Theca rather variable in outline, typically somewhat quadrangular, with convex sides which become concave beneath the broadly rounded or bracket-shaped apex and narrow gradually towards a more or less truncate antapex, sometimes one side is prolonged as an abbreviated horn; a transverse furrow is not indicated.

The capsule fills the theca laterally and is usually broader than long; a slightly polygonal pylome is present near its anterior end. The membrane of the theca is smooth, that of the capsule faintly granular.

Dimensions. Type—theca 71 μ x 52 μ; capsule 38 μ x 50 μ. Range—theca 61-80 μ x 38-53 μ; capsule 32-42 μ x 36-50 μ.

Deflandrea parva sp. nov.

(Pl. IV, figs. 12, 13; holotype, fig. 12)

Age and occurrence. ? Lower Cretaceous (Albian): North of Gingin, W.A., Siltstone from Seismic shot hole B.1 at 230 ft. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), Rough Range Well No. 8 at 1530-48 ft.

Description. Theca smooth, roughly five-sided much as in *D. phosphoritica* or more rounded and elliptical in outline, apex pointed, antapex with a short-pointed horn on one side (Pl. III, fig. 13) or truncate. Transverse furrow rather well developed. Capsule oval, faintly granular not filling the theca laterally.

Dimensions. Type—theca 57 μ x 38 μ; capsule 38 μ x 30 μ. Range—theca 48-57 μ x 33-38 μ.

Deflandrea serratula sp. nov.

(Pl. IV, fig. 4; holotype)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian); Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-86 ft.

Description. The theca is somewhat longer than broad and is widest in the region of the well defined transverse girdle, narrowing from thence towards a prominent apical region which is shaped like a pointed arch, and towards a more or less concave antapex on one side of which is a short pointed horn. A broad longitudinal furrow is present on the hypotheca, but it does not extend to the antapex.

The outer membrane is thin, transparent and rather coarsely granular, but on both sides of the epitheca, between the girdle and the distal limits of the apical arch, it is finely serrated.

The capsule is large in proportion to the size of the theca and extends to the lateral margins. In the type, the position of the future pylome is clearly indicated.

Dimensions. Type—theca 73 μ x 48 μ; capsule 38 μ x 47 μ; pylome 14 μ across.

Genus **Wetzeliella** Eisenack

Wetzeliella irregularis sp. nov.

(Pl. X, figs. 1, 2; holotype, fig. 1)

Age and occurrence. Upper Jurassic: Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2 at 3970-3991 ft.

Description. Shell roughly four-sided with rather abbreviated apical and antapical horns and two more strongly defined lateral horns; the membrane is provided

with somewhat distantly placed bifurcate processes. At the antapex in the type, the processes have fused more or less giving it a somewhat lobed outline.

The capsule is nearly spherical and completely fills the shell, a large pylome is situated near the apex. In two of the four specimens (Pl. X, fig. 2), a "girdle" is faintly indicated.

Dimensions. Holotype—overall length 119 μ (apical horn is turned back), width 133 μ; capsule 85 μ x 81 μ. Paratype (Pl. X, fig. 2)—overall length 107 μ, width 114 μ; capsule 76 μ x 76 μ.

Comments. This form is referred to *Wetzeliella* on account of its squarish outline, the development of four horns, the type of ornament and the presence of an internal capsule. It differs from all other species of the genus in the irregular form of the horns and ornament. *W. irregularis* is to some extent like *Wetzeliella ? neocomica* Gocht (1957) from the Upper Hauterivian of Emsland, Germany. Hitherto *Wetzeliella* has not been known from the Jurassic.

Family Gonyaulacidae

Genus **Gonyaulax** Diesing

Gonyaulax ambigua Defl.

(Pl. III, fig. 1)

Gonyaulax ambigua Deflandre 1941. *Acad. Sci. Inst. Fr.*, Mem. 6; 14, Pl. IV, fig. 6.

Age and occurrence. Upper Jurassic, Dingo Siltstone (Upper), W.A., Wapet's Cape Range Well No. 1 at 3825-40 ft. and Well No. 2 at 3970-91 ft. and 4509-27 ft.; Omati, Papua, I.E.C.'s Well No. 1, samples 24, 27, 36 (Table 1).

Description. Theca broadly oval to almost spherical, epitheca and hypotheca nearly equal, separated by a shallow transverse furrow with low borders; plates delimited by low and narrow membranes. Plates smooth or very faintly granular. The appearance of a short horn is suggested by the projection of the membranes between the apical plates. The exact tabulation has not been determined.

Dimensions. Western Australian examples—81-128 μ x 71-109 μ; New Guinea examples—71-99 μ x 57-71 μ.

Comments. In spite of the fact that the tabulation could not be exactly determined the general features of the Australian specimens clearly indicate identity with *Gonyaulax ambigua*. This species was originally described from the Kimeridgian schists of Orbagnoux, France. Recently the same species has been recorded by Downie (1957) from Kimeridge in England. The Australian examples are considerably larger than the European forms.

Gonyaulax jurassica Defl.

(Pl. II, figs. 9, 10)

Gonyaulax jurassica Deflandre 1938. *C.R. Acad. Sci.* 206; 688, Fig. 2.

Age and occurrence. Upper Jurassic: Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2 at 3970-91 ft. and 6032-60 ft., and Well No. 1 at 3825-40 ft.; Learmonth Formation, W.A., Wapet's Rough Range Well No. 1 at 4376-79 ft.; Broome, Artesian Bore No. 3 at 1405-27 ft. Middle Jurassic: Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1 at 7825-41 ft.

Description. The dimensions, tabulation and ornamentation of the Australian specimens are conformable with those of the holotype and paratypes described by Deflandre (1938) from the French Oxfordian.

Comments. G. jurassica has been recorded by Valensi (1953) from the Bathonian of Lessart, France; by Deflandre (1938, p. 150) from the Dogger of East Prussia and the Oxfordian of Villers-sur-Mer, France; and by Downie (1957) from the Kimeridgian of Kimeridge, England.

Gonyaulax eisenacki Deflandre subspecies **oligodentata** nov. sub. sp.

Gonyaulax eisenacki Deflandre, 1938. *Trav. Stat. Wimereux* 13; 171, Pl. VI, fig. 7.

Age and occurrence. Upper Jurassic: Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.

Description. Two specimens agree so well in shape, size and tabulation with *G. eisenacki* that they can be referred without doubt to this species. However, they differ from it in the smooth or only minutely and sparingly denticulated sutures of the plates and transverse furrow, and for this reason have been separated as a subspecies of the type. In the antapical region the outer membrane reaches considerably beyond the end of the body where, supported by 4 long processes, it forms a hollow cylinder.

Dimensions. Type—96 μ x 57 μ; second specimen—100 μ x 67 μ.

Comments. Gonyaulax eisenacki has been recorded by Deflandre (1938, p. 150) from the Dogger of East Prussia and the Oxfordian of France. An imperfectly preserved specimen from the Bathonian of Lessart, France, has been compared with *G.eisenacki* of Valensi (1953).

Gonyaulax scotti sp. nov.

(Pl. II, figs. 5, 6; holotype, fig. 5.)

Age and occurrence. Upper Jurassic: Dingo Siltstone, Wapet's Cape Range Well No. 2 at 3970-91 ft. and Well No. 1 at 3825-40 ft.

Description. Theca variable in shape but mostly oval; epitheca dome-shaped with a sharply delimited horn, hypotheca more rounded. Wall of theca thick, prolonged at intervals into short, blunt processes and ornamented, especially in the antapical region, by rather delicate processes that are sometimes free but more often confluent forming a loosely constructed or homogeneous membrane. The transverse girdle is narrow and generally obscured by the superficial membrane as frequently are the outlines of the plates.

The tabulation has not been exactly determined but in general conforms to that characterizing the genus *Gonyaulax*.

Dimensions. Type—147 μ x 119 μ. Range—118-156 μ x 114-119 μ. Apical horn 21-24 μ long.

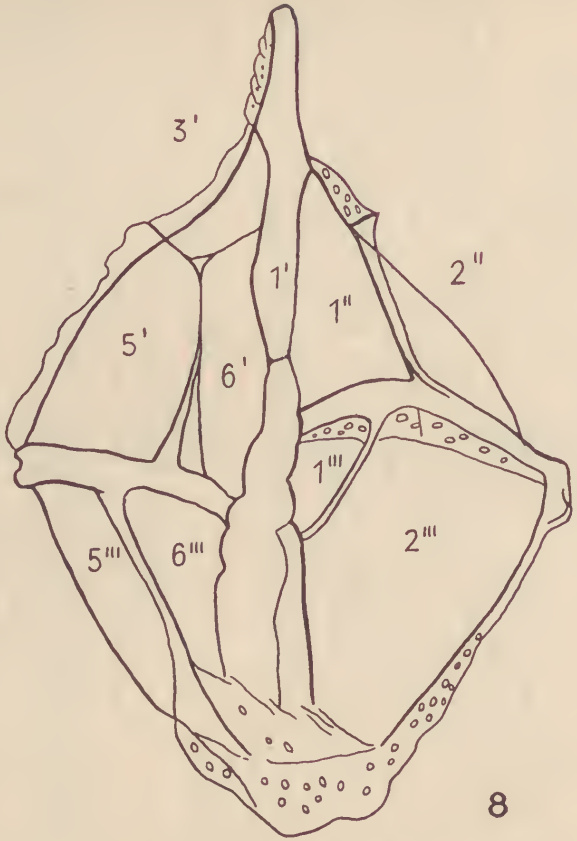
Comments. In its general features *Gonyaulax scotti* agrees with the European Upper Jurassic species *G. cladophora* Defl. but differs in its rather more elongated form and more complex type of ornamentation. In *G. cladophora* the spiny outgrowths delimiting the plates and furrow are free from one another, whereas in *G. scotti* they are usually fused distally forming a delicate membrane.

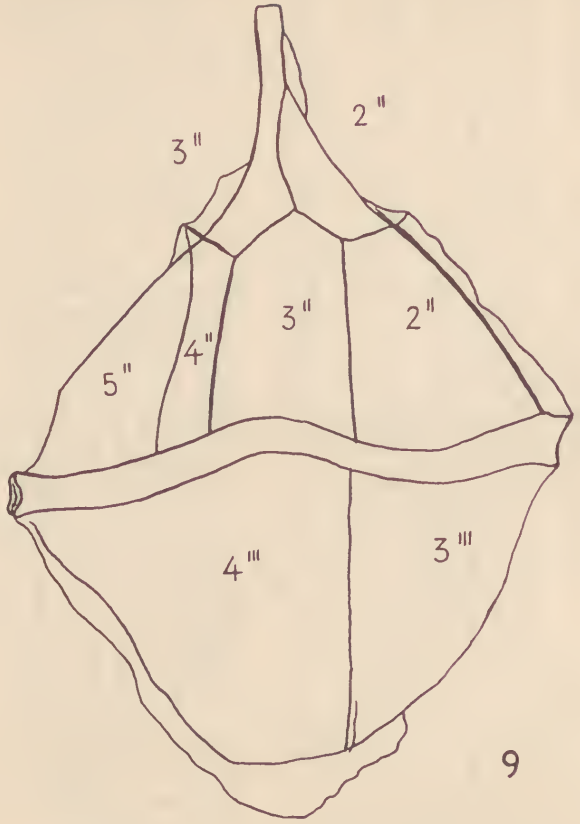
The species is named after Mr. D. H. Scott, late Exploration Superintendent of Wapet.

Gonyaulax perforans

(Pl. II, figs. 1-4, 7, 8; holotype, fig. 1. Figs. 8, 9)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C.'s Well No. 1, sample 31 (Fig. 2).





FIGS. 8-9.—*Gonyaulax perforans* sp. nov. ventral and dorsal surfaces. Omati Bore, Papua, × 680.

Description. Theca longer than broad with a distinctly helicoid girdle. Epitheca conical surmounted by a well-developed bluntly-pointed horn. Hypotheca more rounded than epitheca.

Wall of theca thin, smooth, ornamented to a varying degree by the thin perforated membranes that border the plates and, more especially, the transverse furrow which is frequently almost hidden by a lacy network. A similar ornament is usually well developed in the mid-dorsal region of the hypotheca from which it extends as a prominent projection beyond the antapex.

The longitudinal furrow which passes into the epitheca and to the antapex is unornamented except at the antapex. The plate 1′ which reaches to the horn is especially thin.

In a few specimens (Pl. II, figs. 3, 4) which possibly represent a distinct species, the external ornament is more strongly developed, especially in the region of the girdle.

Dimensions. Type—168 μ x 109 μ. Range—136-168 μ x 93-109 μ.

Comments. Gonyaulax perforans is clearly related to *G. scotti* but differs in its shape, thinner wall, the more prominent antapical boss and the structure of the external ornament. In *G. scotti* the processes of which the membranes ornamenting the theca are constructed, although fused distally, are often individually visible (Pl. II, fig. 5) whereas in *G. perforans* the membranes have a more continuous texture with more or less numerous perforations of various sizes. Furthermore the limits of the plates are more heavily ornamented in *G. scotti* than in *G. perforans.*

Gonyaulax muderongensis sp. nov.

(Pl. III, figs. 3, 4; holotype, fig. 3. Fig. 15)

Age and occurrence. Lower Cretaceous (Aptian): Muderong Shale, W.A., Wapet's Rough Range Well No. 1 at 3863-83 ft.

Description. Theca biconical to oval with a rather long, stiff horn that is closed by a "lid" having a short median terminal projection (Fig. 15); epitheca and hypotheca nearly equal. Girdle narrow, helicoid; longitudinal furrow short, extending somewhat into the epitheca and not reaching the antapex. Plates numerous, slightly granular provided with irregularly distributed short, blunt spiny outgrowths and worm-like surface ridges, sutures thickened. The girdle is bordered on both sides by short regularly arranged processes which are the terminations of the ridges on the surface of the plates adjoining it (Pl. III, fig. 4). Wall of theca moderately thick sometimes with an outer thin transparent ornament formed by the coalescence of fine processes.

Dimensions. Type—147 μ x 105 μ. Range—109-147 μ x 94-105 μ. Apical horn 16-25 μ long.

Gonyaulax edwardsi sp. nov.

(Pl. III, figs. 5, 6; holotype, fig. 6. Fig. 7)

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 5 at 1570 ft. ? Upper Cretaceous (Cenomanian): Subiaco, W.A., Artesian bore at 358 ft. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot holes B.2 at 230 ft. and L.8 at 240 ft. Perth, W.A., King Edward Street Bore at 265-95 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough

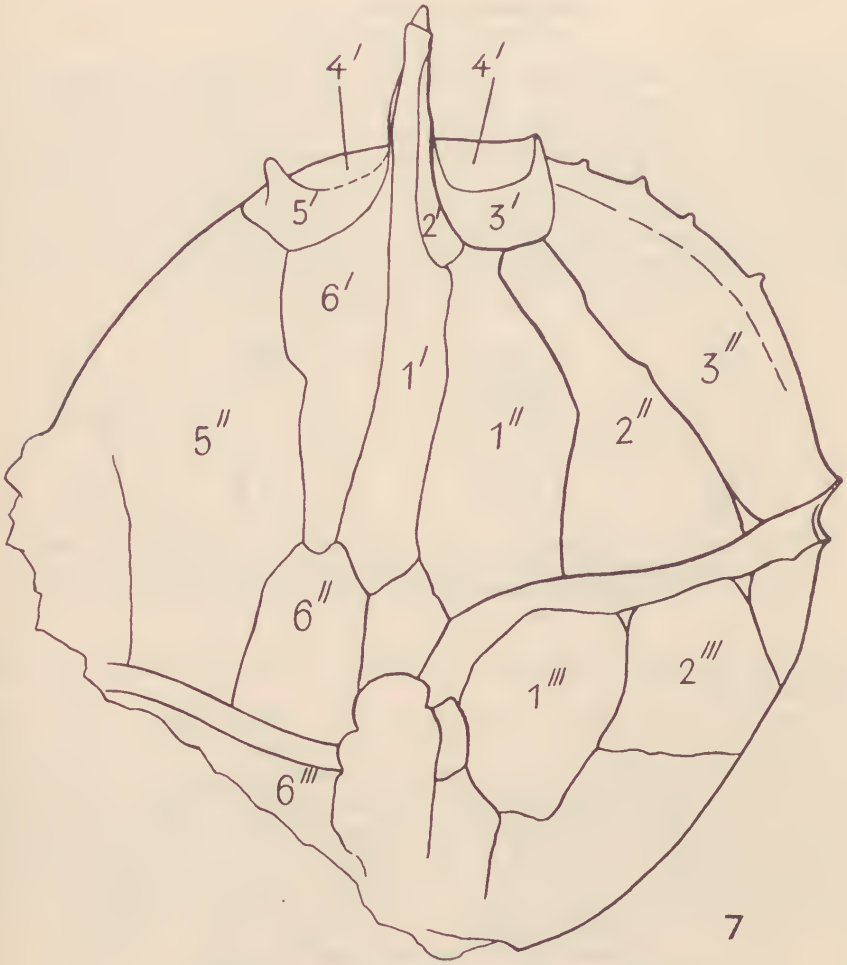


Fig. 7.—*Gonyaulax edwardsi* sp. nov. ventral surface.
Gearle Siltstone (lower part), W.A. × *c.* 870.

Range Well No. 1 at 2000 and 2750 ft.; Styx River Series, Queensland, Queensland Geological Survey Bore No. 21 at 327 ft.

Description. Shell nearly spherical, thick walled. Epitheca with a long, stiff, pointed and sometimes curved horn. Girdle helicoid, narrow with low borders; longitudinal furrow broad. Plates finely granular, the inner surface of girdle sometimes more coarsely granular than the plates. Sutures of the plates with low, thin ledges which often bear a few rather broad, pointed spines especially in the apical and antapical regions.

This species is named after Dr. A. B. Edwards, Officer-in-Charge, Mineragraphic Investigations, C.S.I.R.O., who has forwarded this work.

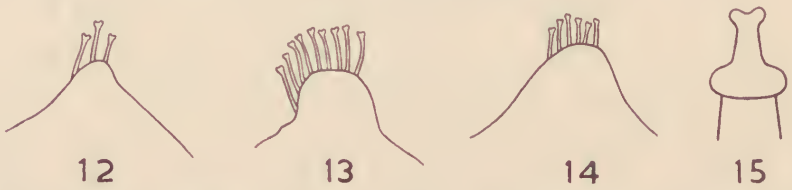
Dimensions. Type—143 μ x 125 μ overall.

Gonyaulax serrata sp. nov.

(Pl. III, fig. 2. Figs. 12-14)

Age and occurrence. Upper Jurassic to possibly Lower Cretaceous (Neocomian); Omati, Papua, I.E.C.'s Well No. 1, samples 19, 20, 25 (Fig. 2).

Description. All the available specimens are flattened and in consequence polygonal in outline. The plates of both epitheca and hypotheca are relatively large and the transverse girdle is helicoid; the longitudinal furrow extends to the antapical plate. The epitheca is terminated by a very short conical process which is covered with spiny projections (Figs. 12-14) and the sutures of the plates and margins of the furrow are ornamented with rather broad comb-like ledges, the teeth of which are either rounded, knob-like or occasionally slightly bifurcate.



FIGS. 12-14.—*Gonyaulax serrata* sp. nov. apical horns of three specimens showing the variation in shape and ornamentation. Omati Bore, Papua, × *c.* 625.
FIG. 15.—*Gonyaulax muderongensis* sp. nov. terminal portion of apical horn. Muderong Shale, W.A., × *c.* 625.

The exact tabulation could not be determined. However, *G. serrata* is a readily recognizable form.

Dimensions. Type—109 μ x 100 μ. Another specimen 100 μ x 94 μ; spines *c.* 2·5-6 μ long.

Comments. Gonyaulax serrata seems to be closely related to *G. cladophora* Defl. from the French Oxfordian. However, it differs from that species in the simpler form and more even length of the spines ornamenting the shell, and in the form of the apical prominence. According to the original diagnosis, *G. cladophora* always has a distinct tubular apical horn. In *G. serrata*, on the other hand, only a short blunt apical prominence surmounted by a few short spines is developed.

Gonyaulax hyalodermopsis sp. nov.

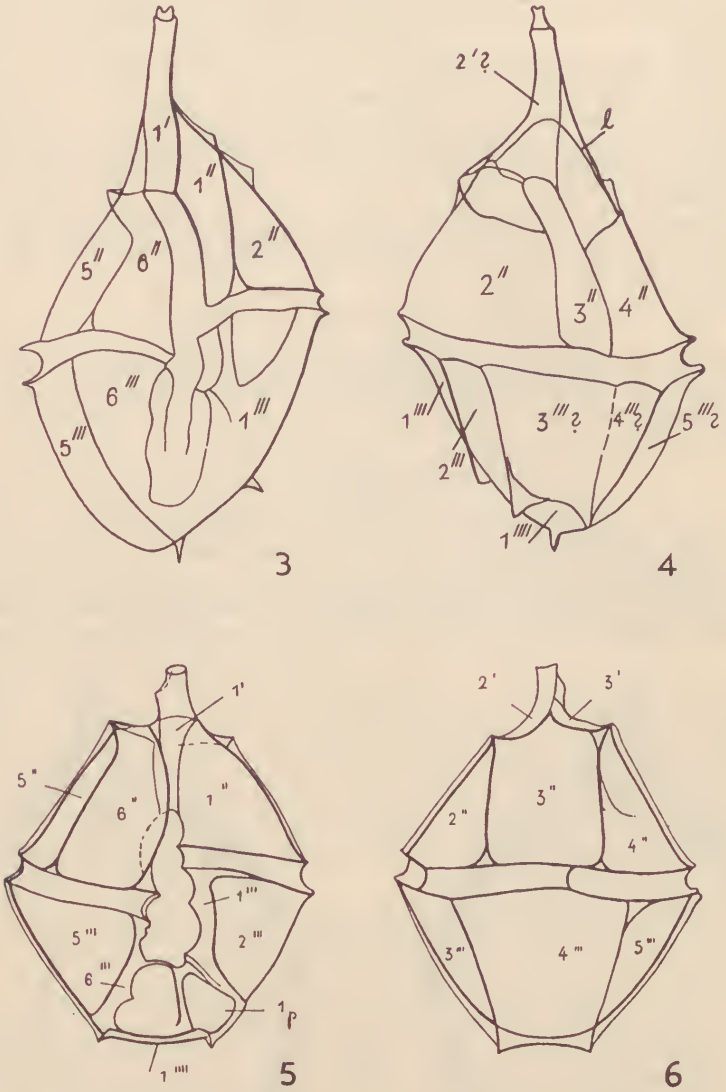
(Holotype—Pl. III, figs. 11, 12. Figs. 5, 6)

Age and occurrence. Lower Cretaceous (Aptian or older): South Perth Formation, W.A., Attadale Artesian Bore at 809 ft. Lower Cretaceous (Upper Neocomian or Lower Aptian): "Grierson Member", Birdrong Formation, W.A., Meadow Station Artesian Bore No. 9.

Description. Theca thin, transparent and smooth, obtusely biconical to slightly oval. Epitheca and hypotheca nearly equal. Apex surmounted by a short cylindrical horn with a pointed apex. Transverse girdle shallow, distinctly helicoid, longitudinal furrow broad. Sutures with smooth, thin and shallow ledges. Dorsal plates very large. The tabulation is shown in Figs. 5, 6.

Dimensions. Type—73 μ x 55 μ overall, horn 9 μ; 62 μ x 47 μ, horn 9 μ.

Comments. In size and shape *G. hyalodermopsis* approaches *Palaeoperidinium hyalodermum* Defl. (1942). However, it cannot be identified with the French Kimeridgian species on account of the imperfect preservation of the type.



FIGS. 3-4.—*Gonyaulax apionsis* sp. nov. ventral and dorsal surfaces. Cootabarlow Bore, S.A., × 680.
FIGS. 5-6.—*Gonyaulax hyalodermopsis* sp. nov. ventral and dorsal surfaces. South Perth Formation, W.A., × 650.

Gonyaulax apionis sp. nov.

(Pl. III, fig. 7; holotype. Figs. 3, 4)

Age and occurrence. Lower Cretaceous (Albian): Cootabarlow, S.A., Bore No. 2 at 600 ft.

Description. Shell smooth nearly twice as long as broad, epitheca long, conical, surmounted by a long, stiff horn which is closed at one end by a "lid" with a short central projection. The girdle is strongly helicoid and bordered by low but rather sharp ledges. The hypotheca is more dome-shaped and the antapical plate is square with 4 small pointed projections at the corners. The ledges bordering the plate are smooth and low.

In the type a long narrow pylome stretches from the base of the horn to the girdle (plate 3″). The tabulation, though rather distinct, cannot be given in full detail; it appears to be simple.

Dimensions. Type—105 μ x 57 μ, horn 20 μ. A paratype—114 μ x 71 μ, horn 24 μ.

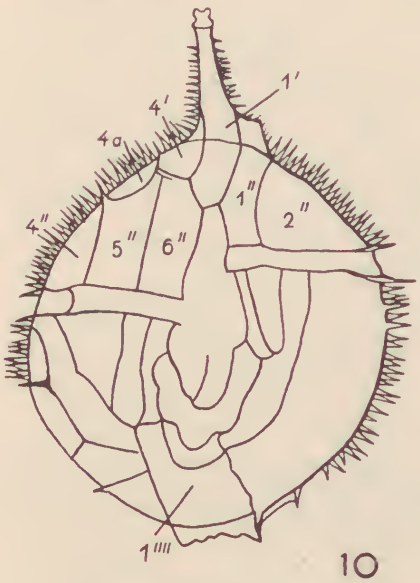
Comments. The long narrow shape, smooth surface and absence of ornamentation distinguish *G. apionis* from all other known fossil species of *Gonyaulax*. A form very similar to it has been recovered by one of us (A.E.) from the Aptian of Northern Germany.

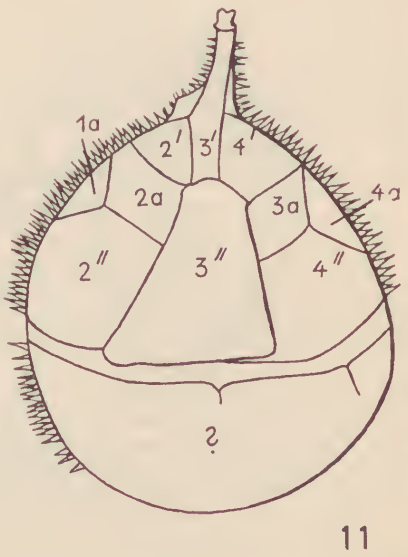
Gonyaulax diaphanis sp. nov.

(Holotype—Pl. III, figs. 13, 14. Figs. 10, 11)

Age and occurrence. Lower Cretaceous (Aptian or older). South Perth Formation, W.A., Attadale Bore at 999 ft.

Description. Shell ovoid, epitheca smaller than hypotheca with a straight, stiff horn. Girdle helicoid. Both the plates and girdle are bordered by spiny ledges, those





Figs. 10-11.—*Gonyaulax diaphanis* sp. nov. ventral and dorsal surfaces. South Perth Formation, W.A., × 525.

around the antapical plate appear to lie obliquely to it. The longitudinal furrow narrows towards the epitheca, and in it the pore for the exit of the flagellum can be seen. The arrangement of the plates is shown in Fig. 10, those on the dorsal surface of the hypotheca are not clear enough for representation.

Dimensions. Holotype—128 μ x 100 μ overall.

Gonyaulax spp.

(Pl. III, figs. 8, 9)

The specimens from Seismic shot hole L.8 at 240 ft. near Gingin, W.A. (Pl. III, fig. 8), and from the Gearle Siltstone (lower part), Rough Range at 2360-75 ft., while providing evidence of their connection with *Gonyaulax,* are not sufficiently well preserved for specific characterization.

Family Hystrichodinidae

Genus **Hystrichodinium** Deflandre

Hystrichodinium amphiacanthum sp. nov.

(Pl. V, fig. 9; holotype)

Age and occurrence. Upper Jurassic or Lower Cretaceous (Neocomian): Omati, Papua, I.E.C.'s Well No. 1, samples 19, 20, 24.

Description. This is a delicate form and most of the specimens are imperfectly preserved. The shell of the type is almost spherical and is provided with a narrow, faintly marked girdle and nine processes, four at one pole and five at the other. The processes are long and pointed, and widen towards the membrane. The membrane of the shell is delicate and no trace of surface markings remains. The main features of this species, i.e., the median girdle and the polar position of the processes, have been confirmed by less perfect paratypes.

Dimensions. Type—173 μ overall; shell 52 μ x 71 μ; processes 43-62 μ long.

Comments. Only two species of *Hystrichodinium* have been described, the genotype *H. pulchrum* Defl. from Senonian and Cenomanian flints of France and Belgium respectively (Deflandre 1936, p. 36), and *H. oligacanthum* Deflandre and Cookson (1955) from the Albian deposit at Onepah Station in New South Wales. In both of these species the processes arise from the general surface of the shell, including the rim of the girdle. In *H. amphiacanthum* they are clearly confined to the polar areas.

Genus **Palaeohystrichophora** Deflandre

Palaeohystrichophora infusorioides Defl.

(Pl. X, fig. 10)

Palaeohystrichophora infusorioides Defl. 1936. *Ann. Paléont* 25; 38, Pl. IX, fig. 8.

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 8 at 1530-48 ft. and Well No. 5 at 1570 ft.

Description. The Australian examples of this species agree closely with the French types from Villers-sur-Mer (Cenomanian Flints) and the Paris Basin (? Senonian Flints) described by Deflandre. As far as can be judged from the magnification of Deflandre's figures (no measurements are recorded in the text), the Australian specimens are somewhat larger than their French counterparts having an overall range in length of 47-71 μ and breadth of 33-57 μ. The example

shown in Pl. X, fig. 10 is 57 μ x 43 μ. *P. infusorioides* occurs abundantly in the upper portion of the Gearle Siltstone.

Palaeohystrichophora isodiametrica sp. nov.

(Pl. XII, figs. 11, 12; holotype, fig. 12)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-88 ft.

Description. The shell is approximately isodiametric and divided somewhat unequally by a straight girdle with low borders; both the epitheca and hypotheca are broadly dome-shaped to flat. The outer membrane, which is thin and transparent and lies close to the internal capsule, especially at the apex and antapex, is covered with numerous long wavy appendages.

The example shown in Pl. XII, fig. 11 has a large trapezoid-shaped pylome which stretches from just below the apex to the girdle.

Dimensions. Type—75 μ x 66 μ; girdle 6 μ; appendages *c.* 24 μ. Paratype (Pl. XII, fig. 11) 70 μ x 71 μ; girdle 5 μ; pylome 28 μ x 20 μ.

Comments. In the type of ornamentation, *Palaeohystrichophora isodiametrica* resembles *P. infusorioides* Defl., but differs from this species in being approximately as long as broad and in having broadly rounded apices and somewhat longer appendages. In *P. infusorioides* as preserved in the Gearle Siltstone, W.A. (Pl. X, fig. 10), the shell is fusiform and the appendages shorter and stiffer.

Palaeohystrichophora multispina Defl. and Cookson

(Pl. X, fig. 13)

Palaeohystrichophora multispina Defl. and Cookson, 1954. *Aus. J. Mar. Freshw. Res.* 6; 257, Pl. I, fig. 5.

Age and occurrence. ? Upper Cretaceous (Senonian): Molecap Greensand, Gingin, W.A. Lower Cretaceous (Albian): Cootabarlow Bore 2 at 581 ft.; Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft.; Well No. 1 at 2750 ft.

Description. During the present investigation a relatively large number of individuals which conform more or less exactly to the original description of *Palaeohystrichophora multispina* have been found. These have provided details that were not evident in the single flattened and broken specimen on which the species was based. The specimen shown in Pl. X, fig. 13 is representative of the new examples.

Extended diagnosis. The theca is broadly fusiform and has straight to convex sides; the "epitheca" is terminated by a shortly bifid process and the "hypotheca" by a sharply pointed spine. The transverse girdle is approximately equatorial but is not helicoid as was suggested as probable in the original description. The theca is covered with short, fine spines which are sometimes so small as to give the surface a granular appearance.

Dimensions. Type—56 μ x 38 μ. Range in new material—62-100 μ x 43-71 μ.

Palaeohystrichophora pellifera sp. nov.

(Pl. X, fig. 11; holotype)

Palaeohystrichophora cf. *spinosissima* Defl. and Cookson, 1955. 6; 258, Pl. IV, fig. 10.
non *Palaeohystrichophora spinosissima* (Defl.) in Deflandre and Cookson, 1955. *Aust. J. Mar. Freshw. Res.* 6; 257.

Age and occurrence. Lower Eocene: Princetown Member of Dilwyn Clay, Vic. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough

Range Well No. 1 at 2000 ft.; Styx River Series, Queensland, Queensland Geol. Surv. Bore 21 at 325 and 327 ft.

Description. The theca is broadly fusiform and divided unequally by the transverse girdle; the "epitheca" is terminated by a shortly bifid process, the "hypotheca" by a short pointed process. The surface is densely covered with spines *c.* 1-2·5 μ long.

Dimensions. Type—85 μ x 59 μ; the "Tertiary" specimen 122 μ x 56 μ.

Comments. From the present investigation it would appear that the genus *Palaeohystrichophora* is restricted to the Cretaceous period. It seems likely, therefore, that the example from the Princetown member of the Dilwyn Clay is a remanié fossil.

Palaeohystrichophora dispersa sp. nov.

(Pl. X, figs. 12, 14; holotype, fig. 14)

Age and occurrence. Probably Lower Cretaceous (Albian); near Gingin, W.A., Seismic shot hole B.2 at 230 ft.; King Edward Street Bore between 265 and 295 ft.

Description. Theca broadly fusiform, unequally divided by the transverse furrow, the larger "epitheca" being terminated by a short bifid process, the hypotheca by a sharply pointed process. The membrane of the theca is ornamented with rather widely dispersed small spine-like processes with truncate apices.

Dimensions. Type—80 μ x 53 μ. Range—64-90 μ x 38-62 μ.

Comments. P. dispersa can be distinguished from *P. pellifera* by the coarser nature of the spines, their truncate apices and wider dispersal.

The three species of *Palaeohystrichophora* just described, namely *P. multispina, P. pellifera* and *P. dispersa,* differ morphologically in several respects from *P. infusorioides* and *P. isodiametrica* and ultimately may prove generically distinct.

Family Incerta

Genus **Dingodinium** gen. nov.

Description. Theca consisting of a smooth, thin, transparent membrane without plates and a spherical to elongate-oval eccentrically placed capsule either covered with numerous small spines or smooth. A helicoid transverse furrow bounded on either side by a more or less distinct fold is always present on the outer membrane. Genotype—*Dingodinium jurassicum* sp. nov.

The name is derived from the Dingo Siltstone of the Cape Range, W.A., Jurassic succession in which the genotype is of frequent occurrence.

Dingodinium jurassicum sp. nov.

(Pl. I, figs. 10, 11; holotype, fig. 10)

Age and occurrence. Upper Jurassic: Dingo Siltstone (Upper), W.A., Wapet's Cape Range Well No. 1 at 3825-40 ft., and Well No. 2 at 3970-91 ft. and 4509-27 ft.; Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.; Omati, Papua, I.E.C.'s Well No. 1, sample 42 (Fig. 2).

Description. Shell usually longer than broad with a shallow girdle. The capsule, which tends to be flattened on the side in contact with the outer membrane, is covered with numerous small irregularly disposed spines.

Dimensions. Type—85 μ x 66 μ; capsule 62 μ x 47 μ. Overall range—76-100 μ x 66-85 μ; capsule 54-71 μ x 47-66 μ.

Dingodinium cerviculum sp. nov.

(Pl. I, figs. 12, 14; holotype, fig. 14)

Age and occurrence. Lower Cretaceous (Aptian): Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.: Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4 at 3532-50 ft.; Wapet's Rough Range No. 4 at 3350 ft.; Omati, I.E.C.'s Well No. 1, samples 5, 9 (Fig. 2); Roma Series, North Queensland, Well on Batavia Downs Station between 45-49 ft.; Cootabarlow, S.A., Bore No. 2 at 1354 ft. Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Bore at 809 ft. Lower Cretaceous (Upper Neocomian or Lower Aptian): "Grierson Member", Birdrong Formation, W.A., Wapet's Well No. 3 at 1390-1400 ft. and Meadow Station Artesian Bore No. 9.

Description. Theca longer than broad, its outer membrane narrowing towards a relatively long terminal neck the end of which, in well preserved specimens, appears to be closed. The girdle is clearly defined and helicoid. The capsule is elongated longitudinally and usually flattened on the side in contact with the outer membrane; it is covered with small spine-like outgrowths which may be arranged in regular longitudinal rows or scattered irregularly over the surface.

Dimensions. Type—109 μ x 66 μ overall; capsule 65 μ x 52 μ. Range—81-109 μ x 33-66 μ; capsule 47-65 μ x 28-52 μ.. Range—81-109 μ x 33-66 μ overall; capsule 47-65 μ x 28-52 μ.

Comments. The real affinity of the genus *Dingodinium* cannot be fixed with certainty. The presence of a girdle indicates relationship with the Dinoflagellata, the occurrence of a capsule within a thin enclosing membrane suggesting a position near the family Deflandreidae.

Palaeoperidinium cf. ventriosum (O. Wetzel)

(Pl. III, fig. 10)

Peridinium ventriosum O. Wetzel, 1933. *Palaeontographica* 77; 161, 162, Fig. 1. 78, Pl. II, figs. 4, 6.

Palaeoperidinium ventriosum G. Deflandre, 1935. *Bull. Biologique,* 69; 228, Pl. V, fig. 5 and Pl. VI, figs. 9, 10.

Age and occurrence. Lower Cretaceous (Aptian): Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.

Description. Shell almost spherical, epitheca slightly conical terminated by a short cylindrical horn with a small conical apex. The girdle is approximately equatorial and has low borders. The longitudinal furrow is indistinct. The sutures of the plates are low and generally masked by the rather coarse granulation of the general surface.

Dimensions. 81 μ x 71 μ.

Comments. The reference of this specimen to the form genus *Palaeoperidinium* is only provisional until such time as more information about it is obtained. *Palaeoperidinium ventriosum* has been recorded from flints of the Baltic region (? Senonian) and of the Paris Basin (? Senonian) (Deflandre 1936, p. 28).

Genus Muderongia gen. nov.

Description. Test flattened, bilaterally symmetrical, composed of a thin outer membrane and an internal body or capsule. The outer membranes prolonged into four equidistant horns and crossed by a narrow shallow girdle. A longitudinal furrow is not developed. Genotype—*Muderongia mcwhaei* sp. nov.

Comments. The external form of *Muderongia* is somewhat similar to that of *Ceratocystidiopsis* Deflandre, *Pseudoceratium* Gocht and *Odontochitina* Defl. However, it is distinct from all three in having a transverse girdle and from *Pseudoceratium* and *Odontochitina* in having an internal capsule.

The taxonomic position of *Muderongia* is uncertain, but its shape and the development of a girdle suggest a connection with the dinoflagellates.

Muderongia mcwhaei sp. nov.

(Pl. VI, figs. 1-5; holotype, fig. 2)

Age and occurrence. Lower Cretaceous (Aptian): Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.; Cootabarlow, S.A., Bore No. 2 at 1165 and 1354 ft. Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Artesian Bore at 809 ft.

Description. The test is roughly rhomboidal in outline and prolonged into two straight median horns (apical and antapical respectively) and two curved and downwardly directed lateral horns of varying lengths; near the points of origin of the horns, smaller more irregular outgrowths may develop (Pl. VI, fig. 3).

The capsule has a smooth, moderately thick wall and entirely fills the central cavity of the test, sometimes even extending into the proximal ends of the horns. The girdle is represented by two fine, closely-opposed, straight lines which completely cross the equator of the test (Pl. VI, fig. 4).

Frequently the extreme distal region of the test becomes detached by a split which develops beneath the base of the apical horn.

The species is named after Dr. Ross McWhae, Geologist, West Australian Petroleum Pty. Ltd.

Dimensions. Type—161 μ x 74 μ overall; apical horn 47 μ long; capsule 62 μ x 57 μ. Other examples—(i) 166 μ x 57 μ overall; apical horn 52 μ long; (ii) 142 μ x 54 μ overall, apical horn 23 μ long.

Genus Broomea gen. nov.

Description. Test elongate with a longer apical horn and two shorter antapical horns. A shallow "girdle" situated below the middle of the body may be present. A pylome is developed in the apical region. Genotype—*Broomea ramosa* sp. nov.

Broomea ramosa sp. nov.

(Pl. VI, figs. 6-8; holotype, fig. 7)

Age and occurrence. Middle Jurassic: Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1 at 6365-83 ft. Upper Jurassic: Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.; Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2 at 3970-91 ft.; Omati, Papua, I.E.C.'s Well 1, samples 19, 27 (Fig. 2).

Description. Body elongate-oval with straight to convex sides narrowing slightly towards the apical horn, broader basally at the place of origin of the antapical horns and divided into two unequal regions—a longer apical region and shorter antapical region—by a shallow "girdle" indicated on the surface by two rather faint parallel straight lines; a somewhat hoof-shaped pylome is developed in the apical region of the same surface.

The apical horn tapers gradually to a short, straight solid terminal point; the two antapical horns which are of unequal size become more or less completely divided longitudinally into a varying number of somewhat ragged, pointed filaments.

The membrane is granular, more coarsely so in the antapical region.

Dimensions. Holotype—214 μ x 38 μ overall; apical horn *c.* 76 μ, larger antapical horn *c.* 38 μ. Range—176-218 μ x 24-38 μ overall; apical horn 76-90 μ.

Broomea simplex sp. nov.

(Pl. VI, fig. 9; holotype)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C.'s Well 1, sample 24 (Fig. 2).

Description. Body broader proximally narrowing towards a long tapering apical horn, antapical horns 2, entire, widely divergent with broad bases and rounded apices. A "girdle" is apparently absent, a pylome is developed in the apical region; the membrane is finely granular.

Dimensions. Type—285 μ x 33 μ overall; apical horn *c.* 118 μ, antapical horns 76 μ x 52 μ. A paratype—314 μ x 33 μ overall; apical horn *c.* 118 μ, antapical horns *c.* 76 μ and 62 μ.

Comments. Our attention was drawn by Professor T. Braarud to the strong morphological agreement, even to the detailed form of the apical horn, that exists between *Broomea ramosa* and *Podolampas spinifer*, Okamura (in Schiller 1937). However, since the fossil specimens referred to as *Broomea ramosa* and *B. simplex* have shown no trace either of the wings accompanying the antapical spines of *P. spinifer* and other species of *Podolampas* or of tabulation, and moreover have a distinct pylome, a feature unknown in *Podolampas*, it seems preferable for the present at least to place the fossils species in a separate genus.

Order Hystrichosphaeridea

Family Hystrichosphaeridae

Genus **Hystrichosphaeridium** Deflandre

Hystrichosphaeridium complex (White)

(Pl. XII, fig. 10)

Xanthidium tubiferum complex White, 1842. *Micr. J.* 2; Pl. IV (3), fig. 11. 1844. *Trans. Micr. Soc.* 1; 83, Pl. VIII, fig. 10.

Hystrichosphaeridium elegantulum Lejeune-Carpentier, 1940. *Ann. Soc. Géol. Belg.* 63; B 222, figs. 11-12.

Hystrichosphaeridium complex (White) Deflandre, 1946. *C.R. Soc. Géol. Fr.*, 111.

H. cf. *tubiferum* sec. Cookson, 1953. Pl. II, fig. 24.

Age and occurrence. Upper Cretaceous: Nelson Bore, Vic., at 5782 and 6192 ft. Upper Cretaceous (? Senonian): Molecap Greensand, W.A. Lower Cretaceous (Albian): Onepah Well, N.S.W.; Styx River Series, Queensland Geological Survey Bore 21 at 327 ft.; Cootabarlow, S.A., Bore No. 2 at 581 ft. and Gearle Siltstone, W.A., Wapet's Rough Range Well No. 1 at 2000 and 2750 ft. Lower Cretaceous (Albian-Aptian): Omati, Papua, I.E.C. Well 1, sample 5 (Fig. 2). Lower Cretaceous (Aptian): Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.; Roma Series, North Queensland, Batavia Downs Station Well between 45 and 49 ft. Lower Cretaceous (Upper Neocomian or Lower Aptian): Grierson Member, Birdrong Formation, W.A., Wapet's Well No. 3 at 1390-1400 ft.

Comments. Hystrichosphaeridium complex was originally recorded from European Upper Cretaceous deposits. The above record has extended its range to cover the greater part of the Cretaceous period. One of us (A.E.) has identified *H. complex* in a north German Aptian deposit.

Hystrichosphaeridium recurvatum (White)

Xanthidium recurvatum White (1842) 1844. *Trans. Micr. Soc.* 1; Pl. VIII, fig. 11.
Hystrichosphaeridium recurvatum (White) Lejeune-Carpentier, 1940. *Ann. Soc. Géol. Belg.* 63; B 221, fig. 6.

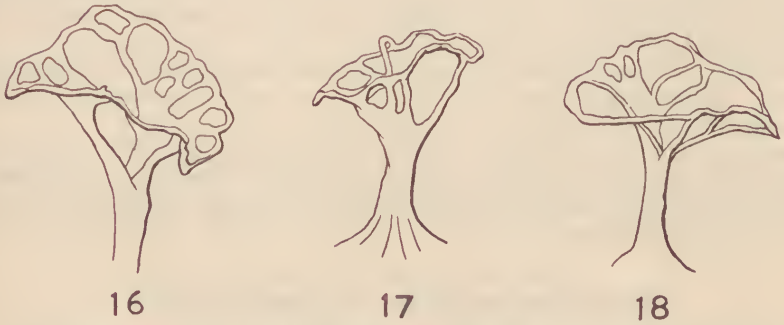
Age and occurrence. Upper Cretaceous (Campanian to Lower Mastrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-88 ft. Upper Cretaceous (? Senonian): Molecap Greensand, Gingin, W.A. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft.; Wapet's Rough Range Well No. 1 at 2750 ft.; Cootabarlow, S.A., Bore No. 2 at 581 ft.; Onepah Well, N.S.W.; Styx River Series, Queensland Geological Survey Bore No. 21 at 327 ft. Lower Cretaceous (Aptian): Roma Series, North Queensland, Well on Batavia Downs Station between 45-49 ft.

Comments. The same two forms of *H. recurvatum* that were observed by Deflandre and Cookson (1955, p. 269), are present in the sediments recorded above. The one with fewer and larger appendages agrees more closely with the type of the species. The other form is readily distinguished by the smaller shell and greater number of finer appendages.

Hystrichosphaeridium anthophorum sp. nov.

(Pl. XI, figs. 12, 13; holotype, fig. 12. Figs. 16-18)

Age and occurrence. Upper Jurassic: Broome, W.A., Artesian Bore No. 3 at 1390-1400 ft. Lower Cretaceous (Aptian-Albian): Omati, Papua, I.E.C. Well 1, samples 5, 9 (Fig. 2).



Figs. 16-18.—*Hystrichosphaeridium anthophorum* sp. nov. undividual appendages. Omati, Papua, × 625.

Description. Shell spheroidal and provided with about 10-15 stalked tubular appendages. The stalks of the appendages which are short and sometimes broad, and frequently show the longitudinal fibrils of which they are composed, gradually widen distally, frequently close to the shell, into deep broad terminal expansions with completely and irregularly reticulate walls and continuous smooth or finely serrated outer edges.

Dimensions. Holotype—Shell 70 μ, overall 210 μ; appendages *c.* 50 μ.

Comments. Hystrichosphaeridium anthophorum is morphologically close to *H. pulcherrimum* Deflandre and Cookson and *H. dictyoplocus* Klumpp. It differs from *H. pulcherrimum* in the more extensive reticulation of the appendages and the entire edge of the terminal expansion, and from *H. dictyoplocus* in the shorter

and somewhat broader appendages and the wider mesh and continuous margin of the terminal expansions.

Hystrichosphaeridium dictyophorum sp. nov.

(Pl. XI, fig. 14; holotype)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C. Well 1, sample 27 (Table 1).

Description. Shell spheroidal, provided with 10-15 appendages which have rather short, apparently solid stems, and abruptly delimited, widely expanded and open meshed terminal expansions with a smooth, continuous edge.

Dimensions. Holotype—diameter shell 71 μ, overall diameter 140 μ; appendages 42-47 μ.

Hystrichosphaeridium siphoniphorum sp. nov.

(Pl. XI, figs. 8-10; holotype, fig. 8)

Age and occurrence. ? Upper Cretaceous (Cenomanian): Subiaco, W.A., Water Bore at 358 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Rough Range Well No. 7 at 2360-75 ft. and Rough Range Well No. 1 at 2000 ft. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot hole L.8 at 240 ft. and B.2 at 230 ft., and Osborne Park, W.A., King Edward Street Bore at 265-95 ft.

Description. Shell spherical or slightly oval, with a rather thick, granular wall, and approximately 13 hollow conical to tube-like processes of somewhat unequal width that are open to the exterior and have a slightly recurved margin. A large pylome has been present in some examples.

Dimensions. Type—overall diameter 76 μ diameter of shell 43 μ, length of processes *c.* 19-24 μ. Paratype (Pl. XI, fig. 9)—overall diameter 69 μ, shell 33 μ length of processes *c.* 14 μ; "lid" of pylome 21 μ.

Comments. This species seems to have some affinity with *H. salpingophorum* Defl., *H. truncigerum* Defl. from the French Upper Cretaceous (Senonian) and *H. striatoconus* Deflandre and Cookson from the Molecap Greensand, W.A., but is clearly distinct from all three species.

Hystrichosphaeridium cf. hirsutum (Ehr.)

(Pl. XI, fig. 13)

Xanthidium hirsutum Ehrenberg 1836. *Abh. Kgl. Akad. Wiss., Berlin, aus. J.* 1836.

Age and occurrence. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot hole B.2 at 230 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft. Lower Cretaceous (Albian-Aptian): Omati, Papua, I.E.C. Well 1, sample 5 (Fig. 2).

Comments. A few specimens have been observed in preparations of the Gearle Siltstone and Omati samples that can be related to the group of *Hystrichosphaeridiums* comprising *Hystrichosphaeridium hirsutum* (Ehr.), *H.* cf. *spinosum* (White), *H.* cf. *spinosum* (White) var. *deflandrei* Lejeune-Carpentier, *H. pseudhystrichodinium* Deflandre and *H. crassipes* (Reade) as reviewed by Lejeune-Carpentier (1941).

The spines of the Australian type agree most closely with those of *H. hirsutum*, *H.* cf. *spinosum* and *H.* cf. *spinosum* var. *deflandrei* but the fibrils that run back

from them on to the surface of the shell, give rise to the same type of surface marking as that present in all members of the *"hirsutum"* group.

Some of these species are not easily separated from one another, so that until more material is available, and comparison with the types and paratypes of the European species is possible, it seems better that the Australian form should not be directly referred to anyone of them.

The European species have only been recorded from the Upper Cretaceous, mainly the Senonian.

Hystrichosphaeridium parvispinum sp. nov.

(Pl. VIII, figs. 10-12)

Holotype: *Hystrichosphaeridium xanthiopyxides* O. Wetzel var. *parvispinum* Deflandre 1937. *Ann. Paléon.* 26; Pl. 13, fig. 5 (Deflandre collection AF31).

Age and occurrence. Lower Cretaceous (probably Aptian): Omati, Papua, I.E.C. Well 1, sample 5 (Fig. 2). Lower Cretaceous (Aptian): Roma Series, Queensland, Batavia Downs Station Well between 45-49 ft.

Description. Shell elongate-oval with a distinctly granular membrane and numerous short, sharply-pointed spines, the tips of which are sometimes recurved (Pl. VIII, fig. 11).

Dimensions. Holotype (estimated from drawing)—shell 40 μ x 20 μ. Australian paratype (Pl. VIII, fig. 10)—84 μ x 46 μ overall, shell 76 μ x 33 μ; a second complete specimen—85 μ x 43 μ overall, shell 73 μ x 32 μ.

Comments. The Australian examples of *H. parvispinum* are undoubtedly specifically distinct from the German Senonian species *H. xanthiopyxides* O. Wetzel. However, apart from their considerably greater size, they appear to be identical with the French specimen described by Deflandre under the name *H. xanthiopyxides* var. *parvispinum*. This is the more probable since both are of Aptian or near Aptian age.

Genus **Coronifera** gen. nov.

Description. Shell roughly oval in outline, with an often denticulate tubular horn at one pole and a stiff pointed process at the other; the surface provided with simple or bifurcate appendages. Genotype *Coronifera oceanica* sp. nov.

Coronifera oceanica sp. nov.

(Pl. XII, figs. 5, 6; holotype, fig. 6)

Age and occurrence. Lower Cretaceous (Albian): Wapet's Rough Range Well No. 7 between 2360-75 ft., Moora Bore between 86 and 170 ft.

Description. In the type specimen, the shell is approximately oval in outline and prolonged at one end into a straight, four-sided tubular horn with a denticulate edge, and at the other into a stiff pointed spine. The surface is granular and covered with rather long and flaccid, thin, simple or more usually bifurcate appendages.

In the specimen shown in Pl. XII, fig. 5, the larger tubular horn is considerably compressed and the pointed spine appears to be missing; in addition, the bases of some of the appendages on one side have fused, forming a denticulated ledge.

Dimensions. Type—90 μ x 81 μ overall; shell 57 μ x 48 μ; hollow horn 17 μ long. Specimen shown in Pl. XII, fig. 5—105 μ x 86 μ overall; shell (without horn) 76 μ x 36 μ; horn 14 μ long.

Comments. A specimen which agrees well with the type of *Coronifera oceanica* has been found by one of us (A.E.) in the Upper Aptian of northern Germany.

Genus **Cannosphaeropsis** O. Wetzel

Cannosphaeropsis utinensis O. Wetzel

Sub-species **filifera** nov. sub. sp.

(Pl. VII, fig. 4; holotype)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-88 ft.

Description. Shell spherical, smooth with a number of processes of unequal lengths and width, which, by their branching and coalescence, give rise to a loose external network. Some of the main branches are flattened and relatively broad; short branches bearing 3 or 4 slender hairs are developed at or near some of the points of branching.

Dimensions. Holotype—overall diameter *c.* 185 μ, diameter of shell *c.* 104 μ.

Comments. Thanks to the co-operation of Dr. Otto Wetzel, it has been possible to compare our specimen with the holotype of *C. utinensis* O. Wetzel which it strongly resembles. The tertiary branchlets however are less frequent than in *C. utinensis* and are filiform and not stiff and spine-like as in that species. The flattening of the supporting processes which is not evident in the holotype of *C. utinensis,* has been shown by Deflandre (1937, Pl. XVI, fig. 12) to occur in a specimen from a Parisian Senonian flint.

Cannosphaeropsis fenestrata Deflandre and Cookson

(Pl. VII, figs. 1-3)

Cannosphaeropsis fenestrata Defl. and Cookson 1955. *Aust. J. Mar. Freshw. Res.*; 283, Pl. III, fig. 2.

Age and occurrence. ? Upper Cretaceous (Cenomanian): Subiaco Water Bore, Perth, W.A., at 358 ft. Upper Cretaceous (? Senonian): Molecap Greensand, Gingin, W.A. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft. Lower Cretaceous (Aptian to Lower Albian): Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4 at 3532-50 ft.

Comments. Five specimens isolated from Western Australian Cretaceous deposits, although not in exact agreement with the type, are referred provisionally to *Cannosphaeropsis fenestrata* described from the Molecap Greensand, W.A. They have rather smaller shells and the threads composing the enveloping network are finer, less flattened and scarcely or not at all perforated. See Appendix 2.

Cannosphaeropsis aemula Defl.

(Pl. VII, fig. 5)

Hystrichosphaeridium aemulum Deflandre 1938. *C.R. Acad. Sci. Paris* 264; 653, Fig. 6.
Cannosphaeropsis aemula Deflandre 1947. *C.R. Acad. Sci. Paris* 224; 1576.

Age and occurrence. Upper Jurassic: Era River district, Papua, Australasian Petroleum Co.'s Wanna Well, sample 451. (The age of this sample was given by Deflandre and Cookson (1955, p. 283) as Lower Cretaceous. We have been informed by Mr. J. N. Montgomery, Geologist to Australasian Petroleum Co., that it is now believed to be Upper Jurassic.) Omati, Papua, I.E.C. samples 19, 20, 26, 31, 33, 35, 36 (Fig. 2); Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2 at 3970-91 ft., 4509-21 ft. and 6030-60 ft., Wapet's Cape Range Well No. 1 at 3825-40 ft.; Broome Artesian Bore No. 3 at 1405-27 ft.

Comments. The specimens of *C. aemula* from the Australian and New Guinea Jurassic deposits, have varied considerably in the degree of development of the funnel-like processes and the profuseness of the connecting threads, but all have possessed the hollow perforated extremities characteristic of this species as described by Deflandre (1938).

According to the records of Deflandre (1938, p. 189), *C. aemula* ranges from the Dogger (East Prussia) to the Oxfordian (Villers-sur-Mer, France).

Cannosphaeropsis aemula sub. sp. **integra** sub. sp. nov.

(Pl. VII, figs. 6, 7; holotype, fig. 6)

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2 at 6032-60 ft. Middle Jurassic (Lower Callovian): Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1 at 6365-83 ft.

Description. Shell spheroidal with a number of hollow, funnel-like processes the walls of which are, for the most part, entire or only very slightly perforated. The "funnels" are connected by short delicate threads.

Dimensions. Overall diameter 95-128 μ, shell 48-62 μ, processes 24-38 μ long.

Comments. The sub-species *integra* is readily distinguishable from typical examples of *C. aemula* such as that shown on Pl. VII, fig. 5 by the rather shorter, broader and more entire processes. It seems to have been a delicate form, for usually the "funnels" and connecting strands are partially destroyed, while those of typical examples of *C. aemula* in the same preparation are intact.

C. aemula sub-species *integra* is the dominant microfossil in the Middle Dingo Siltstone of Cape Range No. 1 Well at 6360 ft., where it is very abundant. It is much less frequent in the Upper Dingo Siltstone of Cape Range Well No. 2 between 6032 and 6060 ft., and has not been observed at higher levels.

Cannosphaeropsis filamentosa sp. nov.

Pl. VIII, figs. 8, 9; holotype, fig. 9. Pl. VIII, figs. 1, 2)

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2 at 6032-60 ft.; Learmonth Formation, W.A., Wapet's Rough Range Well No. 1 at 4376-79 ft. Middle Jurassic (Lower Callovian): Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1 at 6365-83 ft.

Description. Shell approximately spherical, provided with a varying number of thin, solid processes which branch distally, sometimes in a fan-shaped manner, to form by their coalescence an open or sometimes dense enveloping network.

Dimensions. Holotype—overall diameter 124 μ, shell 48 μ.

Comments. C. filamentosa is distinct from *C. aemula* in that the processes supporting the enveloping network are more uniform in size and never possess the hollow extremities of that species. *C. filamentosa* is restricted to the deeper portions of the Cape Range Upper Jurassic sequence, where it occurs together with *C. aemula* and *C. aemula* sub. sp. *integra*, and the upper portion of the Middle Jurassic where it occurs with *C. aemula* sub. sp. *integra*.

In the sample from Rough Range Well No. 1 at 4376-79 ft., *C. filamentosa* alone has been found.

Specimens having the same characters as *C. filamentosa* have been discovered by Mr. Karl Klement of the University of Tübingen in the *Peltoceras transversarium* zone of the lowest part of the Upper Jurassic of Southern Germany (Swabia) (personal communication).

It would appear from the present work that *C. filamentosa* has a more limited range than *C. aemula,* and therefore could be of some stratigraphical value.

Cannosphaeropsis mirabilis sp. nov.

(Pl. VIII, figs. 3-5; holotype, fig. 3)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C. Well No. 1, samples 19, 20, 25, 26, 29 (Fig. 2).

Description. Shell elongate-oval, membrane thin, firm, smooth with 4-6 approximately longitudinal rows of evenly-spaced, solid processes which are connected with one another both proximally and distally by short threads to form a rather small-meshed superficial network. Short spine-like outgrowths are sometimes present on the connecting threads. In the holotype, a pylome appears to be present at one end of the shell.

Dimensions. Type—90 μ x 62 μ overall; shell, 62 μ x 35 μ. Range—90-109 μ x 57-71 μ overall; shell 62-85 μ x 28-52 μ.

Comments. This species, whilst never abundant, is not rare in the upper portion of the Omati Upper Jurassic (Fig. 2). Some of the samples in which it occurs, namely numbers 20, 25, 26 and 29, definitely belong to the Upper Jurassic, but the age of sample 19 is less certain and may be Neocomian. However, the general impression obtained from this study, is that *C. mirabilis* is essentially an Upper Jurassic type.

C. mirabilis is distinct from all known species of *Cannosphaeropsis* in the elongated form of the shell. However, since oval as well as spherical shells are now unquestioningly included in the genus *Hystrichosphaeridium* Defl., it has been considered preferable to enlarge our conception of the genus *Cannosphaeropsis* than to create a new genus for *Cannosphaeropsis-like* forms having shells that are longer than broad.

Genus **Cyclonephelium** Deflandre and Cookson

Cyclonephelium compactum Defl. and Cookson

(Pl. XII, figs. 7, 10)

Cyclonephelium compactum Defl. and Cookson 1955. *J. Mar. Freshw. Res.* 6; 285, Pl .II, figs. 11-13.

Age and occurrence. Upper Cretaceous (? Senonian): Molecap Greensand, Gingin, W.A. Probably Lower Cretaceous (Albian): Osborne Park, W.A., King Edward Street Bore at 265-95 ft.; Gingin, W.A., Seismic shot hole L.8 at 240 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 1 at 2750 ft.; Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft.; Cootabarlow, S.A., Bore No. 2 at 581 ft.; Onepah Well, N.S.W.

Description. Cyclonephelium compactum occurs in most Australian Albian deposits, the example shown in Pl. XII, fig. 7 being typical of the species.

The specimen from the Lower Gearle Siltstone (Pl. XII, fig. 8) varies from the type in the high degree of fusion that has taken place between the processes that form the equatorial ornament and the formation of homogeneous membranes with occasional perforations. The fine fibrils which pass back from the membrane on to the shell, are clearly shown.

The opening in this specimen is sharply defined and appears to have been in the nature of a pylome formed by the complete detachment of the wall of the shell in this

area. The overall diameter of this specimen is 83 μ; the diameter of the shell 75 μ and the opening or pylome 48 μ.

Family Pterospermopsidae

Genus **Pterospermopsis** W. Wetzel

Three species of *Pterospermopsis* have already been described from Australian deposits—one, *P. microptera* Defl. and Cookson from the Lower Tertiary, and two from the Cretaceous, *P. australiensis* Defl. and Cookson from Albian and *P. ginginensis* Defl. and Cookson from ? Senonian deposits.

At the time of their description it was observed that the ratio of wing to body was different in the two Cretaceous species, but from the small number of examples available, the full significance of this distinction could not be estimated.

Further examples of *Pterospermopsis* have been met with during the present investigation, and the genus is particularly well represented in the sample of the "Grierson Member" of the Birdrong Formation, W.A., from the Meadow Bore No. 9. The specimens have varied considerably in size but the majority have greatly exceeded that of both *P. australiensis* and *P. ginginensis*.

Whilst fully realizing that size alone is an unsatisfactory basis for specific determination, the difference here has been so great that we are provisionally distinguishing two additional species—*P. eurypteris* with the same ratio of wing to body as *P. australiensis*, and *P. aureolata* with the same ratio as that of *P. ginginensis*.

Only a detailed statistical study, such as is not possible at present, can determine whether the four types are specifically distinct or only wide variants of two or even one species.

Pterospermopsis aureolata sp. nov.

(Pl. IX, figs. 10-12; holotype, fig. 11)

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), Wapet's Rough Range Well No. 8 at 1530-48 ft. Lower Cretaceous (Aptian): Cootabarlow, S.A., Bore 2 at 1354 ft.; Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.; Roma Series, North Queensland, Batavia Downs Station Bore between 45-49 ft. Lower Cretaceous (Upper Neocomian or Lower Aptian): Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore No. 9.

Description. Body thick-walled, smooth, circular in polar view, with a thin but firm equatorial wing of approximately the same width as the radius of the body.

Dimensions. Overall diameter 109-208 μ, body 62-109 μ; ratio of wing to body 1·4-2.

Pterospermopsis eurypteris sp. nov.

(Pl. VIII, figs. 9, 13; holotype, fig. 13)

Age and occurrence. Lower Cretaceous (Aptian): Cootabarlow, S.A., Bore No. 2 at 1354 ft.; Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4 at 809 ft. Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Bore at 809 ft. Lower Cretaceous (Upper Neocomian or Lower Aptian): Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore No. 9.

Description. Body circular in polar view, smooth, thick-walled, with a rather thick equatorial wing which is approximately equal to the diameter of the body.

Dimensions. Overall diameter 95-123 μ, body 36-49 μ; ratio of body to wing 2·5-2·7.

Genus **Cymatiosphaera** O. Wetzel

Cymatiosphaera pterota sp. nov.

(Pl. XI, fig. 7; holotype)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1384-86 ft. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone, W.A., Wapet's Rough Range Well No. 5 at 1570 ft. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot hole B.2 at 230 ft.

Description. Shell spherical, smooth, its surface divided into large fields by thin, smooth, relatively high membranes perpendicular to the surface. The margins of the membranes are frequently concave and sometimes minutely serrated.

Dimensions. Type—Overall diameter 66 μ, shell 43 μ; overall range 52-85 μ. Ratio of overall diameter to shell 1·4-1·5.

Comments. C. pterota differs from *C. wetzeli* Defl., a German Upper Cretaceous species, in the regular form of the fields and the distinctly higher membranes.

Cymatiosphaera stigmata sp. nov.

(Pl. IX, fig. 14; holotype)

Age and occurrence. Lower Cretaceous (Upper Neocomian or Lower Aptian): Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore No. 9.

Description. Shell spherical, thick-walled, the surface divided by low ledges into numerous polygonal fields (20-40), each of which has a small central thickening of circular outline.

Dimensions. Diameter of type 60 μ; of a paratype 43 μ.

Comments. Cymatiosphaera stigmata agrees with *C. punctifera* Defl. and Cookson from a Victorian Lower Tertiary deposit in having a small thickening in the centre of each field. However, it differs from that species in its larger diameter, in the greater number of fields and the lower ledges.

Cymatiosphaera punctifera	*Cymatiosphaera stigmata*
Diameter of type 23 μ	Diameter of type 60 μ
13 fields	about 40 fields
relatively high ledges	low ledges
Lower Tertiary	Lower Cretaceous

After a careful examination of the type of *C. punctifera*, the conclusion has been reached that there are at most 13 fields and not "17 or 18" as given by Deflandre and Cookson (1955, p. 289).

Genus **Membranilarnax** O. Wetzel

Membranilarnax leptoderma sp. nov.

(Pl. X, figs. 7, 9; holotype, fig. 9)

Age and occurrence. Lower Cretaceous (probably Albian): Omati, Papua, I.E.C. Well 1, sample 2.

Description. Shell rather thick-walled, spheroidal to slightly oval with a granular surface and, in the two specimens available, a large pylome at one pole. The outer thin membrane which envelops the shell, except over the pylome, is supported by very slender, widely separated processes, the ends of which are either bifurcate or slightly broadened.

Dimensions. Holotype—overall diameter 63-68 μ, diameter of shell 50 μ x 46 μ, pylome 25 μ; second specimen—overall diameter 60 μ x 53 μ, diameter of shell 40 μ x 37 μ, pylome 22 μ.

Comments. This species differs from other species of *Membranilarnax* in the rather wide space between the shell and the outer membrane, and the simple and distantly spaced supporting processes.

Membranilarnax sp.

(Pl. X, fig. 8)

Age and occurrence. Lower Cretaceous (probably Albian): Omati, Papua, I.E.C. Well 1, sample 2.

Description. Shell spheroidal with a rather thick granular wall. Enveloping membrane thin and undulating, supported by rather numerous fine processes which divide in such a way as to give a funnel-like appearance. A large pylome is present in the single specimen available.

Dimensions. Overall diameter 71 μ, diameter of shell 45 μ, pylome 24 μ.

Comments. Some uncertainty exists regarding the definition of the genus *Membranilarnax*, and Eisenack (1954) has placed forms comparable with the two forms just described in a separate genus *Samlandia* Eis. However, since, in a previous paper on Australian microplankton (Deflandre and Cookson 1955), species morphologically similar were referred to *Membranilarnax*, the present New Guinea Cretaceous species have been included in that genus pending early investigations of this problem by one of us (A.E.).

Family Leiofusidae

Genus **Leiofusa** Eisenack

Leiofusa jurassica sp. nov.

(Pl. X, figs. 3, 4; holotype, fig. 4)

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 1 at 3825-40 ft. and Well No. 2 at 3970-91 ft. and 4509-27 ft.

Description. Body spindle-shaped, prolonged into two horns of variable length; membrane transparent and smooth. Neither a transverse nor longitudinal furrow developed.

Dimensions. Type—72 μ x 14 μ overall; figured paratype—67 μ x 15 μ.

Comments. Leiofusa jurassica resembles *L. fusiformis* Eis. (1934) from Ordovician deposits of the Baltic region, but is smaller than this species.

It may also be compared with fusiform types described by O. Wetzel (1933) from Senonian flints under the name *Ceratium* cf. *fusus* (Ehr.) of which he has created several forms. However, from Wetzel's descriptions and figures it is not at all clear that, as the name would suggest, the tests had plates and furrows in which eventuality they would be quite distinct from *Leiofusa jurassica.*

The French Cretaceous form ? *Ceratium* cf. *fusus* (Ehr.) forma *incerta* Defl. is another fusiform type, the morphological characters of which are not sufficiently defined for comparison with *Leiofusa jurassica.*

Genus **Pyxidiella** gen. nov.

Description. Shell longer than broad, with straight or convex sides and rounded ends behind one of which a pylome is developed. Genotype—*Pyxidiella pandora* sp. nov.

Pyxidiella pandora sp. nov.

(Pl. VI, figs. 10, 11; holotype, fig. 10)

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2 between 3970-91 ft. and 4509-27 ft.; Era River District, Papua, Australasian Petroleum Co., Wana Well, sample 451.

Description. Shell cylindrical, with broadly rounded ends and a squarish pylome just behind one of them. Wall thin but firm, densely covered with small granules.

Dimensions. Type—48 μ x 32 μ. Range—48-57 μ x 24-43 μ.

Comments. Pyxidiella pandora is the most frequent individual type in the upper portion of the Dingo Siltstone where it occurs in very large numbers. Such an abundance would suggest that it represents a simple independent organism. The constant occurrence of a pylome, and its mode of development, suggest a relationship with the Hystrichosphaeridae.

Pyxidiella scrobiculata (Deflandre and Cookson)

Leiosphaera scrobiculata Deflandre and Cookson 1955. *Aust. J. Mar. Freshw. Res.* 6; 291, Pl. III, fig. 3.

Comments. The Upper Cretaceous and Tertiary shells described by Deflandre and Cookson (1955) appear to be related to *Pyxidiella*. For this reason they have been removed from *Leiosphaera* (Eisenack 1938), a genus which we think should be used, as originally intended, for spherical forms only.

Incertae Sedis

Nannoceratopsis pellucida Defl.

(Pl. X, figs. 5, 6. Fig. 19)

Nannoceratopsis pellucida Defl. 1938. *Trav. Stat. Zool. Wimereux* 13; 183, Pl. VIII, fig. 10.

Age and occurrence. Upper Jurassic: Dingo Siltstone (upper), W.A., Wapet's Cape Range Well No. 2 at 3970-91 ft. and 6032-60 ft.; Broome, W.A., Artesian Bore No. 3 at 1405-27 ft.; Omati, Papua, I.E.C. Well 1, samples 31, 35 (Fig. 2).

Comments. The Australian and New Guinea specimens although varying somewhat amongst themselves and from the French types are in sufficient agreement for reference to *Nannoceratopsis pellucida* from the Oxfordian of Villers-sur-Mer, France. A few of those from New Guinea have widely diverging antapical horns (Pl. X, fig. 6), however, it has not been possible to determine the constancy of this feature.

Previously *N. pellucida* has been known only from the one French locality. Its relatively frequent occurrence in deposits so far distant as north-west Western Australia and New Guinea is therefore of some geographical and possibly of stratigraphical interest.

Dimensions. Figured specimens—Pl. X, fig. 5, 125 μ x 57 μ; antapical horns 35 μ; Pl. X, fig. 6, 100 μ x 62 μ.

Genus **Ceratocystidiopsis** Deflandre

Ceratocystidiopsis ludbrooki sp. nov.

(Pl. V, figs. 7, 8; holotype, fig. 7)

Age and occurrence. Probably Lower Cretaceous (Albian): North of Gingin, W.A., shale from seismic shot hole B.1 at 230 ft.; Osborne Park, W.A., King Edward Street Bore at 265-95 ft. Lower Cretaceous (Albian): Cootabarlow, S.A.,

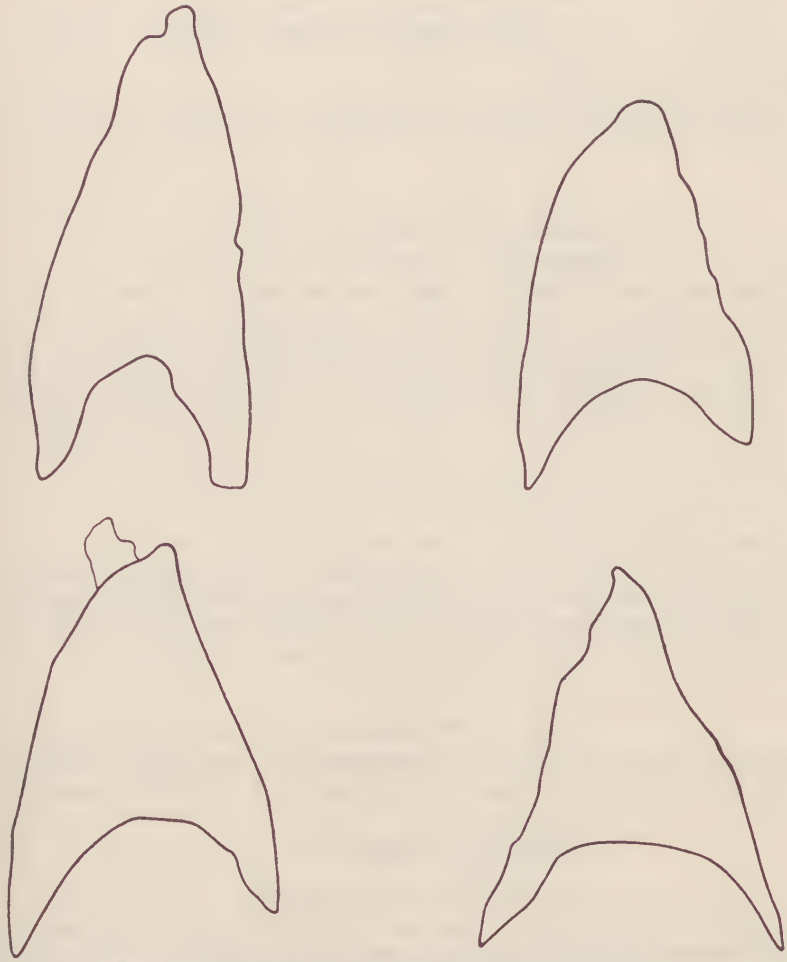


Fig. 19.—*Nannoceratiopsis pellucida* sp. nov. showing variation in shape of the test. Omati, Papua and Dingo Siltstone, W.A., × 500.

Bore 2 at 581 ft.; Gearle Siltstone (lower part), W.A., Rough Range Well No. 7 at 2360-75 ft.; Gearle Siltstone, Rough Range Well No. 1 at 2000 ft.

Description. Theca approximating in outline to an isosceles triangle with convex sides, a rather blunt obliquely directed apical horn and two divergent and somewhat unequal antapical horns with more pointed apices.

The internal capsule is sub-triangular with a flat base, convex sides and a blunt apex and is separated from the outer membrane by a space of variable width. The wall of the internal body is finely granular, that of the outer membrane smooth.

The apical region of the theca may become completely detached along an irregular line that extends obliquely across its upper portion (Pl. V, fig. 8).

The species is named after Dr. Nell Ludbrook, Palaeontologist, Dept. of Mines, South Australia.

Dimensions. Type—Overall length 190 μ, width of body 104 μ; apical horn *c.* 62 μ long; apical horn *c.* 33 μ; length of capsule *c.* 90 μ. Paratypes—Overall length 166 μ, width of body 109 μ; apical horn 57 μ; overall length 142 μ, width of body 85 μ; apical horn 38 μ.

Comments. *Ceratocystidiopsis ludbrooki* agrees in general features with *C. molesta* Defl. (1937) from the French Senonian, but differs from it both in size and shape.

Genus **Odontochitina** Deflandre

Odontochitina operculata (O. Wetzel)

Odontochitina operculata (O. Wetzel). *Aust. J. Mar. Freshw. Res.* 6; 291.

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 5 at 1570 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 1 at 2000 ft. and 2750 ft.; Cootabarlow, S.A., Bore No. 2 at 581 ft.; Onepah Station, N.S.W.; Tooloombah Creek Area, Styx Coalfield, Queensland, Queensland Geological Survey Bore 21 at 327 ft. Probably Lower Cretaceous (Albian): Osborne Park (King Edward Street) Bore at 265-95 ft.; Omati, Papua, I.E.C. Well 1, sample 2 (Fig. 2).

Comments. This species was recorded from the Onepah well sample by Deflandre and Cookson in 1955. Since then examples have been isolated from the widely separated localities listed above. It would appear from these records that in the Australian area *Odontochitina operculata* is an Albian-Lower Turonian species. In Europe it has, so far, been recorded only from Senonian deposits.

Genus **Korojonia** gen. nov.

Description. Shell consisting of a smooth transparent broadly fusiform to oval membrane and an oval internal capsule. Genotype—*Korojonia dubiosa* sp. nov.

Korojonia dubiosa sp. nov.

(Pl. XII, fig. 13; holotype)

Age and occurrence. Upper Cretaceous (Campanian to Lower Maestrichtian): Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 between 1380-88 ft. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 5 at 1570 ft.

Description. Outer membrane broadly fusiform with blunt apices one of which sometimes carries a minute projection. The internal capsule is oval and thicker walled than the outer membrane from which it is separated by a rather wide space. Sometimes faint indications of an equatorial girdle can be seen at each side of the shell.

In most of the specimens, as in the type, the outer membrane of one side is partially folded over the shell.

Dimensions. Type—86 μ x 48 μ overall; cyst 48 μ x *c.* 33 μ. Range—66-95 μ x 38-48 μ overall.

Comments. *Korojonia dubiosa* seems to be related to the genus *Deflandrea* in some members of which, e.g. *D. bakeri* Defl. and Cookson, the two antapical horns typical of the genus as well as the girdle are considerably reduced or absent.

Genus **Pseudoceratium** Gocht

Pseudoceratium tetracanthum Gocht

Pseudoceratium tetracanthum Gocht, 1957. *Paläont Z.*, 31; 163-185.

Age and occurrence. Lower Cretaceous (Aptian): Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4 at 3532-50 ft.; Roma Series, Queensland; Well on Batavia Downs Station between 45-49 ft. Lower Cretaceous (probably Aptian): Omati, Papua, I.E.C. Well No. 1, samples 5, 9 (Fig. 2).

Description. The Australian and New Guinea specimens agree in every respect with *Pseudoceratium tetracanthum* from the Upper Hauterivian (Neocomian) of Emsland in north-western Germany. Usually the specimens are found with the apical region detached but even then are readily recognizable by the slender form of the horns and the delicate body membrane. In these features, apart from the increased number of horns, *P. tetracanthum* is distinct from *Odontochitina operculata* (O. Wetzel) with which species it appears to have a close affinity.

Dimensions. Figured specimen—overall length 242 μ, length of body 90 μ, width of body 61 μ, apical horn 95 μ.

Pseudoceratium turneri sp. nov.

(Pl. V, figs. 2-6; holotype, fig. 3)

Age and occurrence. Lower Cretaceous (Albian): Gearle Siltstone, W.A., Wapet's Rough Range Well No. 1 at 2750 ft.; Onepah Well, N.S.W.; Cootabarlow S.A., Bore 2 at 581 ft.; Styx Series, Queensland, Queensland Geological Survey Bore 21 at 327 ft. Lower Cretaceous (probably Albian): Omati, Papua, I.E.C. Well No. 1, sample 4 (Fig. 2); Wapet's Moora Bore, W.A., between 86 and 170 ft. Lower Cretaceous (Aptian): Roma Series, Queensland; Well on Batavia Downs Station between 45-49 ft.

Description. Test either subtriangular with an oblique base and convex sides, prolonged into three horns of unequal length, a longer apical horn and two widely separated divergent antapical horns, or with a rounded base and one antapical horn. Frequently the apical region of the body becomes detached (Pl. V, fig. 6) near the base of the apical horn.

The ornament usually takes the form of narrow lamella-like membranes with irregular, frequently curved outlines of variable lengths formed by the distal coalescence of short bifurcate processes, the lamellae either remaining free or uniting to form a more or less complete superficial network.

Dimensions. Type—180 μ x 100 μ overall; apical horn 55 μ.

Comments. This very characteristic and variable form although referred to the genus *Pseudoceratium* on account of its shape and absence of an internal capsule is distinct from described European species in the type of ornamentation. It comes nearest in this respect to *P. pelliferum* Gocht but in this species the processes forming the ornament are always free from one another whereas in *P. turneri* they are usually united.

The species is named after Professor J. S. Turner of the University of Melbourne.

Genus **Fromea** gen. nov.

Description. Shell elongated, smooth with an equatorial "girdle" and a wide aperture at one end. Genotype—*Fromea amphora* sp. nov.

Fromea amphora sp. nov.

(Pl. V, figs. 10, 11; holotype, fig. 10)

Age and occurrence. ? Upper Cretaceous (Cenomanian): Subiaco, W.A., Artesian Bore at 358 ft. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot hole L.8 at 240 ft. and Gingin, W.A., Seismic shot hole B.1 at 230 ft; Moora Bore between 86 and 170 ft. Lower Cretaceous (Albian): Cootabarlow, S.A., Bore No. 2 at 581 ft.; Gearle Siltstone (lower part), W.A., Rough Range Well No. 7 at 2360-75 ft. and Well No. 1 at 2750 ft.; Onepah Station Well, N.S.W. Lower Cretaceous (Aptian): Roma Series, Cape York Peninsula, Well on Batavia Downs Station between 45 and 49 ft.

Description. Shell ellipsoidal, flattened, concave in the apertural region; wall *c.* 3 μ slightly thicker around the aperture. Equatorial "girdle" strongly indicated in the type, less so in other examples.

Dimensions. Type—81 μ x 62 μ; apertures 33 μ. Range—62-95 μ x 47-81 μ.

Comments. Deflandre (1937) has described under the name *Palaeostomocystis* small shells from the French Upper Cretaceous which have the general morphological features of *Fromea*. However, the latter is distinguished from *Palaeostomocystis* by the development of an equatorial "girdle".

Fromea amphora has a wide distribution in Australia mainly in deposits of Albian age. Its occurrence in the Roma Series of North Queensland (attributed to the Aptian), gives an Aptian-? Cenomanian time range, but although it is known from Albian and possibly younger deposits in Western Australia, it has not been observed in such Aptian deposits as the Muderong Shale or Windalia Radiolarite of that State.

Genus **Chlamydophorella** gen. nov.

Description. Shell enclosed in a delicate membrane that is supported by closely arranged slender, bifurcate spines of approximately equal length. Genotype—*Chlamydophorella nyei* sp. nov.

Chlamydophorella nyei sp. nov.

(Pl. XI, figs. 1-3; holotype, fig. 1)

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 5 at 1570 ft.; Wapet's Rough Range Well No. 8 at 1530-48 ft. ? Upper Cretaceous (Cenomanian): Subiaco, W.A., Water Bore at 358 ft. Probably Lower Cretaceous (Albian): Gingin, W.A., Seismic shot hole B.2 at 230 ft. and L.8 at 240 ft.; Moora Bore, W.A., between 86-170 ft. Lower Cretaceous (Albian): Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7 at 2360-75 ft.; Cootabarlow, S.A., Bore No. 2 at 581 ft.; Onepah Well, N.S.W. Lower Cretaceous (Aptian): Roma Series, Queensland, Batavia Downs well, Cape York Peninsula between 45 and 49 ft. Lower Cretaceous (probably Aptian): Omati, Papua, I.E.C. Well 1, sample 5 (Fig. 2). Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Bore at 809 ft.

Description. The shell is approximately spherical with a short peltate apical projection and is covered with numerous short, slender bifurcate processes which support a delicate membrane. The processes narrow from base to apex and are mostly inserted at right angles to the shell, but in the apical region lie parallel to the polar axis. The length of the spines differs slightly. They are longest on either

side of the equatorial region giving a slightly angular outline to the whole body and a median "girdle"-like appearance in optical section.

Dimensions. Type—48 μ x 43 μ overall; shell 38 μ x 35 μ; appendages 2·5-5 μ. Paratype (Pl. XI, fig. 2)—48 μ x 43 μ.

Comments. This type was previously recorded and figured by Deflandre and Cookson (1955, p. 273, Pl. VII, fig. 12) from the Onepah Well deposit, N.S.W., when the "angular outline recalling that of certain dinoflagellates" was noted. However, the specimens then available were considered insufficient for description and classification. Even now, when a relatively large number of specimens from a number of localities have been observed, only two have been found lying so as to give a proper idea of the shape of the organism.

The affinity of *Chlamydophorella nyei* is still obscure, its bilateral symmetry, rather angular outline and the suggestion of a "girdle", favour a connection with the dinoflagellates.

The fossil figured (Pl. XI, fig. 4) under the name *Chlamydophorella* ? sp., seems to be a species of that genus which has developed a large opening or pylome as the result of the breaking away of the apical region. It differs from *C. nyei* in the shorter, stouter and less numerous processes which bear the outer thin, transparent membrane. It seems probable that the shells of *C. nyei* opened in a similar manner.

The species is named after Mr. P. B. Nye, Director of the Bureau of Mineral Resources, Department of National Development, Commonwealth of Australia.

Genus **Wanaea** gen. nov.

Description. Shell hollow, widely cone-shaped, the edge almost but not completely surrounded by a lace-like edging, a length of about 24 μ being devoid of ornamentation (Pl. IX, fig. 7). The edging, which is of variable width, is composed of radially arranged processes that either anastomose or remain free. The existence of a closing membrane has been suggested by one specimen. Genotype—*Wanaea spectabilis* (Deflandre and Cookson).

Comments. In its general morphology *Wanaea* approaches most closely to the genus *Epicephalopyxis* of Deflandre. However, it differs from this genus in having a conical instead of a dome-shaped form, and in the presence of a lace or fringe-like edging. Furthermore, the forms included in *Wanaea* are obviously planktonic, whereas the genotype of *Epicephalopyxis, E. adherens* Defl., is an attached form.

Wanaea spectabilis (Defl. and Cookson)
(Pl. IX, fig. 1)

Epicephalopyxis spectabilis Deflandre and Cookson 1955. *Aust. J. Mar. Freshw. Res.* 6; 293, Pl. III, figs. 12-14.

Age and occurrence. Upper Jurassic: Era River District, Papua, Australasian Petroleum Company's Wana Wall sample 451; Omati, Papua, I.E.C. samples 36, 40, 42 (Fig. 2); Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2 at 6032-60 ft.

Description. When this species was first described, the material available gave only a partial idea of the form of the shell as a whole. Now better preserved examples, isolated from the Omati deposits, have shown that it is widely cone-shaped with a small rounded apex (Pl. IX, fig. 1). As noted in the original description, the lacey edging is composed of radially arranged and sometimes bifurcate processes which are distally united.

Dimensions. Type—overall 110 μ x 84 μ, edging *c.* 8 μ. Paratype (Pl. VIII, fig. 1)—Depth 85 μ, maximum width 95 μ, width of edging *c.* 5 μ.

Wanaea digitata sp. nov.

(Pl. IX, figs. 2-5; holotype, fig. 2)

Age and occurrence. Upper Jurassic: Learmonth Formation, W.A., Wapet's Rough Range Well No. 1 at 4376-79 ft.; Broome, W.A., Artesian Bore No. 3 between 1405-27 ft.

Description. Shell broadly cone-shaped, narrowing towards a short, rounded apex; the edge is ornamented by a narrow fringe composed of finger-like or pointed processes which, although they may anastomose tangentially or coalesce proximally, remain free distally.

Dimensions. Holotype—depth 100 μ width 109 μ. Paratype (Pl. VIII, fig. 3)—width 110 μ; edging about 9·5 μ.

Comments. This species differs from *Wanaea spectabilis* in the structure of the ornament. In *W. spectabilis* the processes are united distally so that the edge of the "lace" is entire, whereas in *W. digitata*, although the bases of the processes may be united, the edge of the ornament is always frayed.

Wanaea clathrata sp. nov.

(Pl. IX, figs. 6-8; holotype, fig. 6)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C. samples 20, 26, 35 (Fig. 2); Dingo Siltstone (upper), W.A., Wapet's Cape Range Well No. 1 at 3825-40 ft. and Well No. 2 at 3970-91 ft. and 4509-45 ft.

Description. Shell narrowing to a rounded apex. Edging in the form of a relatively wide, rather irregularly constructed, small-meshed network with an entire edge, which narrows gradually towards the gap where it is entirely wanting (Pl. IX, fig. 7).

Dimensions. Holotype—depth 95 μ, maximum width 161 μ. Paratypes—147 μ wide, edging 24-33 μ.

Comments. The three species of *Wanaea* just considered appear to form an evolutionary sequence in which *W. digitata* is the simplest and *W. clathrata* the most highly developed form. This idea is supported, to some extent, by the stratigraphical occurrence of these species in the Omati and Cape Range Upper Jurassic deposits. In these, *W. spectabilis* appears to be restricted to the lower horizons (samples 36, 40, 42 (Fig. 2) in Omati Well No. 1 and to 6032-60 ft. in the Cape Range Well No. 2 sequence), whereas *W. clathrata* has been found only at higher levels (Omati samples 20, 26, 35 and Cape Range Well No. 2 at 3970-91 ft. and 4509-45 ft.).

Unfortunately the age of the Rough Range (No. 1 Well at 4376-79 ft.) and Broome (Oxfordian to Lower Kimeridgian according to Teichert (1940) and Tithonian according to Brunnschweiler (1945)) deposits, in which *W. digitata* occurs, is uncertain, but it is doubtful whether either is high in the Upper Jurassic.

Genus **Cyclodictyon** gen. nov.

Description. Microfossil consisting of a spherical or oval shell and a hollow-domed, equatorially-attached network. Genotype—*Cyclodictyon paradoxos* sp. nov.

Cyclodictyon paradoxos sp. nov.

(Pl. XII, figs. 1, 2; holotype, fig. 1)

Age and occurrence. Upper Cretaceous (Cenomanian to Lower Turonian): Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 5 at 1570 ft.; Rough Range Well No. 8 at 1530-48 ft.

Description. Shell small, smooth, thin-walled, compressed to an oval outline in all specimens. The net which is fine-meshed, folded and concavo-convex, is attached near the ends of the shell by broad, smooth, entire or occasionally divided, curved supporting strands which carry it well above the shell, so that its inner concave edges are separated from the shell by a considerable space.

The space separating the two sides of the net from one another has been small in all examples, but it seems highly probable that in life it was larger.

Dimensions. Type—overall 71 μ x 71 μ; shell 30 μ x 19 μ. Paratype—overall 76 μ x 71 μ; shell 33 μ x 24 μ.

Comments. In all, thirteen examples of this type have been found in samples of the Cenomanian to Lower Turonian portion of the Gearle Siltstone from two separate bores. The affinity of *Cyclodictyon paradoxos* is obscure, and it cannot be placed in any of the recognized families of fossil or living microplankton.

Genus **Dioxya** gen. nov.

Description. Shell fusiform, without plates and girdle, and with the two ends closed and of different shapes. Genotype—*Dioxya armata* sp. nov.

Dioxya armata sp. nov.

(Pl. XI, fig. 11. Holotype, Fig. 20)

Age and occurrence. Lower Cretaceous (probably Albian): Omati, Papua, I.E.C. Well 1, sample 2 (Fig. 2).

Description. Shell broadly fusiform with one end sharply pointed and smooth, the other broader, slightly truncate and with a few small terminal spines. The surface is covered with relatively thick, finger-like or occasionally pointed outgrowths, which in the type are irregularly arranged, and in other specimens are in parallel equatorial rows. The wall is rather thick, firm and transparent. In the type, the outline of a small squarish pylome is suggested near the more pointed end of the shell.

Dimensions. Type—55 μ x 40 μ overall. Paratype— 48 μ x 38 μ overall.

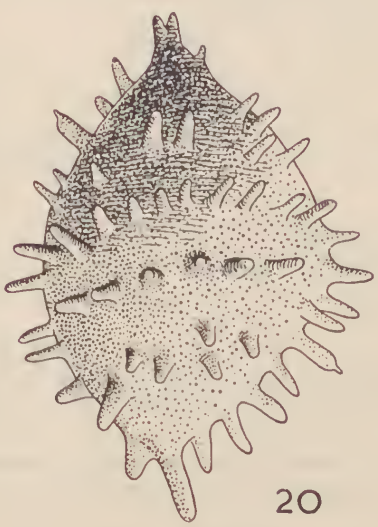


Fig. 20.—*Dioxya armata* Omati, Papua, × 1300.

Genus **Pareodinia** Deflandre

Pareodinia aphelia sp. nov.

(Pl. XII, figs. 3, 4, 9; holotype, fig. 4)

Age and occurrence. Lower Cretaceous (? Aptian): South Perth Formation, W.A., Attadale Bore at 999 ft. Upper Jurassic: Learmonth Formation, W.A., Wapet's Rough Range Well No. 1 at 4376-79 ft.; Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2 at 3970-91 ft. and 6032-60 ft. Middle Jurassic: Dingo Siltstone (middle part), W.A., Wapet's Cape Range Well No. 1 at 6365-83 ft.

Description. Shell with an acuminate or rounded apex and a short closed neck. Wall varying somewhat in thickness and firmness, granular to almost smooth.

Dimensions. Type—88 μ x 50 μ. Paratype (Pl. X, fig. 14)—105 μ x 52 μ. Range—66-114 μ x 33-62 μ.

Comments. It seems probable that this species, when better known, will be split into two distinct species (1) typified by the example taken as the present type (Pl. XII, fig. 4) in which the apex is rounded, the neck abruptly delimited and the wall firm and moderately thick, and (2) typified by the example illustrated in Pl. XII, fig. 9, in which the apex is acuminate, the wall thin, delicate and more strongly granular. However, other examples are less readily separable so that for the present at least, it seems better to include both forms in one broadly defined species.

Pareodinia aphelia is very similar to *P. ceratophora* Defl. from Upper Callovian deposits of the Baltie region and French Bajocian flints, and there is little doubt that the two species are closely related. *P. aphelia* is somewhat larger than *P. ceratophora.*

The specimen described by Deflandre (1938) from the French Oxfordian as *Palaeoperidinium spinosissimum* and later transferred by him to *Palaeohystrichophora* (Deflandre and Cookson 1955) is very similar to the example of *Pareodinia aphelia* shown in Pl. XII, fig. 9, only the occurrence of a girdle, said to be present in the French species, separating the two forms.

Genus **Omatia** gen. nov.

Description. Shell more or less fusiform, partially or completely covered by a delicate fin-like membrane. Genotype—*Omatia montgomeryi* sp. nov.

Omatia montgomeryi sp. nov.

(Pl. VIII, figs. 7-9; holotype, fig. 8)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C. Well 1, samples 25, 20, 19 (Fig. 2).

Description. Shell slightly pointed or with a short truncate neck at one end rounded at the other; surface granular, covered more or less completely by a narrow and delicate membrane which is supported by short, thin, simple or bifurcate processes which tend to be arranged in longitudinal rows. The membrane is widest and the processes most numerous at the two ends of the shell.

The species is named after Mr. J. N. Montgomery, geologist to Australasian Petroleum Co. Ltd.

Dimensions. Holotype—124 μ x 38 μ. Range 76-124 μ x 29-45 μ.

Omatia pisciformis sp. nov.

(Pl. VIII, fig. 6; holotype)

Age and occurrence. Upper Jurassic: Omati, Papua, I.E.C. Well 1, sample 20.

Description. Apex of shell broadly rounded, with a short, pointed, solid process which supports the outer membrane; antapex bluntly pointed. Shell membrane granular, thin outer membrane homogeneous, apparently restricted to the apical and antapical regions. In the single specimen available a large pylome is situated to one side of the mid-line and slightly below the apex; the "lid", which is oval in outline, is partially detached.

Dimensions. Holotype—142 μ long.

Comments. Omatia pisciformis differs from *O. montgomeryi* principally in the homogeneous texture of the thin outer membrane. No sign of the supporting processes evident in *O. montgomeryi* has been observed.

Microplankton Assemblages

The lists included in this section are intended as indications and not as complete representations of the microplankton assemblages present in the various deposits analysed. This applies particularly to the Gearle Siltstone and Korojon Calcarenite which are rich in Hystrichosphaerids the majority of which have been ignored during the present work. Species marked * have been recorded from the French Oxfordian. Species marked † have been recorded from the French and English Kimeridgian.

A. Jurassic.

(i) Dingo Siltstone, Western Australia.

(a) Cape Range Well No. 1 at 6032-60 ft. and Well No. 2 at 6365-83 ft.

The microplankton at these levels is not rich in types and the preservation of those present is poor. The following forms have been recognized:

Dinoflagellata: *Gymnodinium crystallinum**; *Gonyaulax jurassica**†.

Hystrichosphaeridae: *Cannosphaeropsis aemula**, *C. aemula* sub. sp. *integra*, *C. filamentosa.*

Incertae Sedis: *Wanaea spectabilis* (6032-60 ft. only); *Broomea ramosa*; *Pareodinia aphelia.*

(b) Cape Range Well No. 2, 3970-91 ft.

This deposit contains a rich and varied assemblage and deserves fuller investigation. The types present are representative of the samples of the Upper Dingo Siltstone from Cape Range Well No. 1 at 3825-40 ft. and Well No. 2 at 4509-27 ft.

The Microplankton includes:

Dinoflagellata: *Gymnodinium crystallinum**, *G. luridum**; *Wetzeliella irregularis*; *Gonyaulax ambigua**, *G. jurassica**†, *G. scotti*; *Dingodinium jurassicum.*

Hystrichosphaeridae: *Cannosphaeropsis aemula**.

Leiofusidae: *Leiofusa jurassica*; *Pyxidiella pandora.*

Incertae Sedis: *Nannoceratopsis pellucida**; *Wanaea clathrata*; *Broomea ramosa*; *Pareodinia aphelia.*

(ii) Learmonth Formation, Western Australia. Rough Range Well No. 1 at 4376-79 ft.

The amount of organic material in this deposit was very small and some of the types present were too badly preserved for accurate identification.

The microplankton includes:

Dinoflagellata: *Gonyaulax jurassica**†.

Hystrichosphaeridae: *Cannosphaeropsis filamentosa.*

Incertae Sedis: *Wanaea digitata*; *Parcodinia aphelia.*

(iii) Broome, Western Australia. Bore No. 3 at 1405-27 ft.

This deposit of which only a small sample was available contains a well preserved microflora and microplankton assemblage. Several types have still to be classified.

The microplankton includes:

Dinoflagellata: *Gymnodinium crystallinum**, *G. luridum**, *G. parvimarginatum*; *Gonyaulax ambigua*†, *G. jurassica**†, *G. eisenacki* sub-species *oligodentata*; *Dingodinium jurassicum.*

Hystrichosphaeridae: *Hystrichosphaeridium anthophorum*; *Cannosphaeropsis aemula**.

Incertae Sedis: *Nannoceratopsis pellucida**; *Broomea ramosa*; *Wanaea digitata*; *Parcodinia aphelia.*

(iv) Omati, Papua. I.E.C. Well 1.

Although there is good palaeontological evidence that the upper limit of the Upper Jurassic in the Omati Well is at or near the level of sample 24 (Fig. 2), its exact position is not known with certainty. As far as the microplankton content is concerned, it has been found that some of the types present in or below sample 24 occur as high in the bore as sample 19, and for present purposes this level has been taken as the upper limit of the Jurassic, and not as Lower Cretaceous (Neocomian) as it may well be. Unfortunately no surely dated Neocomian deposits have been available for study, so that, as yet, we have no idea of the microplankton types that occurred in Australian waters during that period.

Most of the spores and microplankton in the Omati deposits are unfavourably preserved, and this applies especially to species of *Gonyaulax*, only two of which were sufficiently well defined for description. It is of interest to note the apparent absence of *Gonyaulax jurassica* from the Omati Jurassic sediments, a species that is well represented in Western Australian and European Jurassic deposits.

The microplankton includes:

(a) Samples 40-43 (Fig. 2).

Dinoflagellata: *Dingodinium jurassicum* (one example only).

Hystrichosphaeridae: *Cannosphaeropsis aemula**.

Incertae Sedis: *Wanaea spectabilis.*

(b) Samples 20-35 (Fig. 2).

Dinoflagellata: *Gymnodinium crystallinum** (Samples 24, 35); *Gonyaulax perforans* (Sample 31 only), *G. serrata* (Samples 20, 25).

Hystrichosphaeridae: *Cannosphaeropsis aemula**, *C. mirabilis* (Samples 20, 25, 26, 29).

Incertae Sedis: *Ornatia montgomeryi* (Samples 20, 25), *O. pisciformis* (Sample 20); *Broomea ramosa* (Sample 27), *B. simplex* (Sample 24); *Wanaea clathrata* (Samples 20, 26, 35).

(c) Sample 19 (Fig. 2).

Dinoflagellata: *Gonyaulax serrata*; *Hystrichodinium amphiacanthum.*

Hystrichosphaeridae: *Cannosphaeropsis aemula*, C. mirabilis.*

Incertae Sedis: *Ornatia montgomeryi*; *Broomea ramosa.*

B. Cretaceous.

1. Lower Cretaceous.

(a) Upper Neocomian or Lower Aptian.

(i) Probably "Grierson Member" of Birdrong Formation, W.A., Meadow Station Bore No. 9.

The microplankton content is high with *Deflandrea cincta* as the dominant type. It includes:

Dinoflagellata: *Gonyaulax hyalodermopsis*; *Deflandrea cincta*; *Dingodinium cerviculum.*

Pterospermopsidae: *Pterospermopsis aureolata, P. eurypteris*; *Cymatiosphaera stigmata.*

(ii) "Grierson Member", Birdrong Formation, W.A., Wapet's Well No. 3 at 1390-1400 ft.

Unlike the sample from Meadow Station Bore No. 9, this deposit has a low microplankton content and high spore content and, on this account, has been given only a cursory examination. The types isolated include:

Dinoflagellata: *Dingodinium cerviculum.*

Hystrichosphaeridae: *Hystrichosphaeridium complex.*

Pterosphermopsidae: *Pterospermopsis aureolata.*

(b) Aptian.

(i) Muderong Shale, W.A., Wapet's Rough Range Well No. 8 at 3863-83 ft.

The microplankton includes:

Dinoflagellata: *Gonyaulax muderongensis*; *Dingodinium cerviculum*; *Palaeoperidinium* cf. *ventriosum*; *Muderongia mcwhaei.*

Hystrichosphaeridae: *Hystrichosphaeridium complex.*

(ii) Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4 at 3532-50 ft.

The microplankton includes:

Dinoflagellata: *Dingodinium cerviculum.*

Hystrichosphaeridae: *Cannosphaeropsis fenestrata.*

Incertae Sedis: *Pseudoceratium tetracanthum.*

(iii) Rough Range Well No. 4 at 3350 ft.

From the occurrence of *Dingodinium cerviculum* and *Pseudoceratium tetracanthum* at this level, we judge that this deposit is of approximately the same age as the Windalia Radiolarite, which it overlies.

(iv) South Perth Formation, W.A., Attadale Bore at 809, 999 ft.

This deposit contains rather more spores than microplankton but the latter is sufficiently characteristic to suggest that its age is not younger than Aptian. Included in it are:

Dinoflagellata: *Gymnodinium attadaleuse*; *Gouyaulax hyalodermopsis, G. diaphanis* (999 ft.); *Dingodinium cerviculum*; *Muderongia mcwhaei.*

Pterospermopsidae: *Pterospermopsis eurypteris.*

Incertae Sedis: *Pareodina aphelia*; *Chlamydophorella nyei, C.* sp.

(v) Roma Series, North Queensland, Batavia Downs Station, Cape York Peninsula between 45 and 49 ft.

This deposit needs further investigation and a detailed comparison with the typical occurrence of the Roma Series in southern Queensland. The microplankton, which appears to contain a mixture of Aptian and Albian species, includes:

Dinoflagellata: *Dingodinium cerviculum.*

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. parvispinum*; *Cyclonephelium compactum.*

Pterospermopsidae: *Pterospermopsis aureolata.*

Incertae Sedis: *Pseudoceratium turneri, P. tetracanthum*; *Chlamydophella nyei*; *Fromea amphora.*

(vi) Cootabarlow, S.A., Bore 2 at 1354 ft.

The age of the sample at this depth has been estimated by Dr. N. Ludbrook as Aptian on the basis of the contained arenaceous foraminifera (unpublished information, South Australian Department of Mines). The microplankton is in complete agreement with this finding. It includes the following types:

Dinoflagellata: *Dingodinium cerviculum*; *Muderongia mcwhaei.*

Hystrichosphaeridae: *Hystrichosphaeridium complex.*

Pterospermopsidae: *Pterospermopsis aureolata, P. eurypteris.*

(vii) Omati, Papua, I.E.C. Well 1, samples 9 and 5. The microplankton includes:

Dinoflagellata: *Dingodinium cerviculum.*

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. authophorum.*

Incertae Sedis: *Pseudoceratium tetracanthum.*

In containing *Dingodinium cerviculum* and *Pseudoceratium tetracanthum* these deposits are linked with the Windalia Radiolarite of Western Australia and the Roma Series of North Queensland.

(c) Albian.

(i) Gearle Siltstone (lower part), W.A., Wapet's Rough Range No. 7 at 2360-75 ft.; Rough Range No. 1 at 2000 and 2750 ft.

These deposits contain rich and varied microplankton assemblages. The spore content on the other hand is relatively low.

The microplankton includes:

Dinoflagellata: *Gonyaulax edwardsi*; *Palaeohystrichophora multispina.*

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. recurvatum, H. siphoniphorum, H.* cf. *hirsutum* (Well No. 7 at 2360-75 ft.); *Coronifera oceanica* (Well No. 7 at 2360-75 ft.); *Cannosphaeropsis fenestrata* (Well No. 7 at 2360-75 ft.); *Cyclonephelium compactum.*

Insertae Sedis: *Pseudoceratium turneri* (Well No. 1 at 2750 ft.); *Ceratocystidiopsis ludbrooki* (Well No. 7 at 2360-75 ft.); *Odontochitina operculata*; *Fromea amphora*; *Chlamdophorella nyei.*

(ii) Cootabarlow, S.A., Bore 2 at 581-600 ft.

This portion of the Cootabarlow bore No. 2, as well as containing numerous spores and pollen grains, has a varied and well characterized microplankton content which is closely comparable with that of the lower portion of the Gearle Siltstone of Western Australia. Since the age attributed to the latter, on palaeontological grounds, is Albian there is a strong probability that the age of the Cootabarlow sediments in question is also Albian.

The microplankton includes:

Dinoflagellata: *Gonyaulax edwardsi, G. apionis*; *Palaeohystrichophora multispina.*

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. pulcherrimum, H. recurvatum*; *Cyclonephelium compactum.*

Pterosperopsidae: *Pterospermopsis australiensis.*

Incertae Sedis: *Ceratocystidiopsis ludbrooki*; *Odontochitina operculata*; *Pseudoceratium turneri*; *Fromea amphora*; *Chlamydophorella nyei.*

(iii) Styx River Series, Queensland. Queensland Geological Survey Bore 21 at 327 ft.

The microplankton types recovered from this sample strongly support the Albian age originally suggested for the Styx Series by Walkom (1919). They include:

Dinoflagellata: *Gonyaulax edwardsi*; *Palaeohystrichophora pellifera.*

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. recurvatum.*

Incertae Sedis: *Pseudoceratium turneri*; *Odontochitina operculata.*

(iv) Omati, Papua (Fig. 2).

Sample 4. The frequent occurrence of *Pseudoceratium turneri* in this deposit is suggestive of an Albian age.

Sample 2. The microplankton includes:

Dinoflagellata: *Gonyaulax* cf. *apionis*; *Palaeohystrichophora multispina.*

Hystrichosphaeridae: *Hystrichosphaeridium parvispinum, H.* cf. *hirsutum*; *Membranilarnax leptoderma.*

Incertae Sedis: *Dioxya arnata*; *Odontochitina operculata*; *Pseudoceratium turneri.*

Several of these species occur in Australian Albian deposits.

(d) Probably Albian.

This estimation has been based on the contained microplankton assemblages, which agree fairly closely, as far as the main types are concerned, with that in the Gearle Siltstone (lower part), W.A.

(i) Near Gingin, W.A., Seismic shot hole L.8 at 240 ft.

Dinoflagellata: *Gonyaulax edwardsi.*

Hystrichosphaeridae: *Hystrichosphaeridium siphoniphorum*; *Cyclonephelium compactum.*

Incertae Sedis: *Fromea amphora*; *Chlamydophorella nyei.*

(ii) Near Gingin, W.A., Seismic shot hole B.2 at 230 ft.

Dinoflagellata: *Deflandrea parva*; *Gonyaulax edwardsi*; *Palaeohystrichophora dispersa.*

Hystrichosphaeridae: *Hystrichosphaeridium siphoniphorum*; *Cymatiosphaera pterota.*

Incertae Sedis: *Ceratocystidiopsis ludbrooki*; *Odontochitina operculata*: *Chlamydophorella nyei*; *Fromea amphora.*

(iii) North-east of Gingin, W.A., Moora bore between 86 and 170 ft.

This sample is highly carbonaceous with a preponderance of woody tissue, a rather well characterized microplankton assemblage and a low proportion of spores and pollen grains.

The microplankton includes:

Dinoflagellata: *Gonyaulax edwardsi*; *Palaeohystrichophora multispina*; *Hystrichodinium oligocanthum* Defl. and Cookson (1955).

Hystrichosphaeridae: *Hystrichosphaeridium complex, H. pulcherrimum* Defl. and Cookson (1955), *H. recurvatum*; *Coronifera oceanica*; *Cyclonephelium compactum.*

Incertae Sedis: *Pseudoceratium turneri; Odontochitina operculata*: *Chlamydophorella nyei*; *Fromea amphora.*

(iv) Osborne Park, W.A., King Edward Street bore between 265-95 ft.

Dinoflagellata: *Gonyaulax edwardsi*; *Palaeohystrichophora dispersa.*

Hystrichosphaeridae: *Hystrichosphaeridium siphoniphorum*; *Cyclonephelium compactum.*

Incertae Sedis: *Ceratocystidiopsis ludbrooki*; *Odontochitina operculata*; *Chlamydophorella nyei.*

(v) Subiaco, W.A., Water Bore at 358 ft.

The age of this deposit is uncertain. It is linked by the occurrence of *Deflandrea acuminata* with the upper Cenomanian part of the Gearle Siltstone, and by *Ceratocystidiopsis ludbrooki* with the lower Albian part of the Gearle Siltstone, but unfortunately the upper limit of the latter species and the lower limit of the former is not known. On the whole, the Subiaco deposit has more types in common with the lower part of the Gearle Siltstone than with the upper part, and it seems likely that its age approximates more closely to Upper Albian than to Lower Cenomanian.

The microplankton includes:

Dinoflagellata: *Deflandrea acuminata*; *Gonyaulax edwardsi*; *Palaeohystrichophora* cf. *multispina*.

Hystrichosphaeridae: *Hystrichosphaeridium siphoniphorum*; *Cannosphaeropsis fenestrata*.

Incertae Sedis: *Fromea amphora*; *Odontochitina operculata*; *Ceratocystidiopsis ludbrooki*.

2. Upper Cretaceous.

(a) Cenomanian to Lower Turonian. Gearle Siltstone (upper part), Wapet's Rough Range Well No. 5 at 1570 ft. and Well No. 8 at 1530-48 ft.

The microplankton, which at both these levels is moderately rich and varied with *Palaeohystrichophora infusorioides* of the French Cenomanian as the dominant type, includes:

Dinoflagellata: *Gymnodinium westralium*; *Deflandrea acuminata, D. parva*; *Gonyaulax edwardsi* (Well No. 5 at 1570 ft.); *Palaeohystrichophora infusorioides*.

Pterospermopsidae: *Cymatiosphaera pterota*.

Incertae Sedis: *Chlamydophorella nyei*; *Odontochitina operculata*; *Cyclodictyon paradoxos*; *Korojonia dubiosa* (Well No. 5 at 1570 ft.).

(b) Campanian to Lower Maestrichtian. Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4 at 1380-88 ft.

The most noticeable change in the microplankton content of this deposit is the appearance of three species of *Deflandrea* not observed in older sediments, and the apparent absence of *Gonyaulax* spp. which have been conspicuously present in all the lower horizons. The microplankton includes:

Dinoflagellata: *Gymnodinium westralium*; *Deflandrea pellucida, D. korojonensis, D. serratula*; *Palaeohystrichophora isodiametrica*.

Hystrichosphaeridae: *Hystrichosphaeridium recurvatum*.

Pterospermopsidae: *Cymatiosphaera pterota*.

Incertae Sedis: *Korojonia dubiosa*.

Conclusions

A. *Stratigraphical*

This study of the series of dated Upper Mesozoic samples, provided by West Australian Petroleum Pty. Ltd. from exploratory wells in the Exmouth Gulf area of Western Australia, clearly shows that the microplankton assemblages of the individual horizons and some of the species composing them, have a restricted vertical distribution. With one doubtful exception, none of the species occurring in the Middle and Upper Jurassic parts of the Dingo Siltstone of Cape Range extends into the Lower Cretaceous, provided the Neocomian or Lower Aptian age suggested for the Birdrong Formation is correct. A restriction of types likewise occurs in the Cretaceous sediments. Species such as *Dingodinium cerviculum, Muderongia mcwhaei* and *Pseudoceratium tetracanthum* have not been observed in beds younger than Aptian, while *Palaeohystrichophora multispina, Cyclonephelium compactum,*

Ceratocystidiopsis ludbrooki, Odontochitina operculata (Senonian in Europe) and *Pseudoceratium turneri* appear to be typical Albian species.

In addition, the discovery in Western Australia of types identical with ones occurring in European deposits of approximately the same ages, has reaffirmed the usefulness of microplankton in intracontinental correlations previously noted by Deflandre and Cookson (1955). Several examples can be cited:

(1) The species *Gymnodinium crystallinum, Gymnodinium luridum, Gonyaulax jurassica, Cannosphaeropsis aemula* and *Nannoceratopsis pellucida* which are associated together in the French Oxfordian, are also relatively common in the Upper Dingo Siltstone of Cape Range Wells Nos. 1 and 2, the age of which is thought to be Middle or Lower Kimeridgian. However, as only two of the species occurring in the Dingo Siltstone have been recorded from European Kimeridgian deposits, namely *Gonyaulax jurassica* and *Gonyaulax ambigua* from the Kimeridge clay of England (Downie, 1957) and *Gonyaulax ambigua* from Kimeridgian calcareous schists of France (Deflandre, 1941), the possibility of an Oxfordian age for the deposit in Cape Range Well No. 1 between 3900 and 4318 ft. and Well No. 2 between 3970 and 4527 ft. needs to be considered.

(2) Another close approximation is provided by the occurrence in Australian and Papuan deposits of *Pseudoceratium tetracanthum* from the upper Hauterivian (Neocomian) of north-western Germany (Gocht, 1957). This species is abundant in such Aptian deposits as the Windalia Radiolarite of Rough Range, W.A., the Roma Series of North Queensland, and the Papuan Omati samples 9, 5.

(3) The occurrence of *Coronifera oceanica* in the Gearle Siltstone (lower part) and in an Aptain deposit from northern Germany provides a further connection between the fossil microplankton of the northern and southern hemispheres.

(4) An even more exact correlation can be established between the French Cenomanian and the Cenomanian to Lower Turonian portion of the Gearle Siltstone (Rough Range Well No. 8 at 1530-48 ft. and Well No. 5 at 1570 ft.), by the occurrence in both of *Palaeohystrichophora infusorioides,* a species not at yet recorded from any other deposits.

Hitherto, no palaeontological correlations between Papuan and Western Australian Upper Mesozoic deposits have been made (Mr. J. N. Montgomery personal communication). Now, as the result of the present study, it can be shown that the Omati and Exmouth Gulf deposits have a number of microplankton types in common.

The upper samples of the Jurassic section of the Omati core (Nos. 24-35) agree with those of the upper Dingo Siltstone, W.A. (Cape Range Well No. 2, 3970-4527 ft.) in containing *Wanaea clathrata* together with *Gymnodinium crystallinum, Cannosphaeropsis aemula, Broomea ramosa* and *Nannoceratopsis pellucida,* whilst the lower samples (Nos. 36-42), like that of Cape Range Well No. 2 at 6032-60 ft., contain *Wanaea spectabilis.*

In the Cretaceous section of the Omati Core (sample No. 9, 5), the occurrence of *Dingodinium cerviculum* and *Pseudoceratium tetracanthum* supports a correlation with the Windalia Radiolarite of Rough Range and the Roma Series of North Queensland, while the occurrence of *Pseudoceratium turneri* in Sample 4 and of *Palaeohystrichophora* cf. *multispina, Hystrichosphaeridium* cf. *hirsutum* and *Odontochitina operculata* in Sample 2 permits correlation with the lower part of the Gearle Siltstone.

An opportunity to evaluate the role of microplankton in local stratigraphy has been afforded during the present investigation of Western Australian sediments, the age of several of which has been uncertain.

(1) The deposit between 1405 and 1427 feet in the Broome Artesian No. 3.

A difference of opinion exists regarding the age of this deposit, Teichert (1941, 1947) having suggested that it is Oxfordian to Lower Kimeridgian and Brunnschweiler (1954) that it is Tithonian. The microplankton, in containing the French Oxfordian species *Gymnodinium crystallinum, Gymnodinium luridum, Gonyaulax eisenacki*, sub. sp. *oligodentata* and *Cannosphaeropsis aemula*, as well as the Upper Dingo Siltstone species *Dingodinium jurassicum* and *Pareodinia aphelia*, supports an Oxfordian rather than a Tithonian age. A correlation with the Learmonth Formation (Rough Range No. 1 between 4376 and 4379 ft.) can be made on the basis of *Wanaea digitata*, a species that has not been found in any of the other deposits.

(2) South Perth Formation.

(a) Attadale bore between 809 and 999 ft.

Prior to the present investigations the age of this formation was not known precisely. Crespin (in Parr 1938) attributed a Lower Cretaceous age to the unit. The evidence of the contained microplankton is in agreement with this finding. Through the association in it of *Dingodinium cerviculum* and *Muderongia mcwhaei*, a correlation can be established with the Aptian Muderong Shale of W.A. and the siltstone intersected by the Cootabarlow (S.A.) No. 2 bore at 1354 ft., the age of which has been determined as Aptian by Dr. Nell Ludbrook (unpublished information, South Australian Department of Mines) on the basis of the abundant arenaceous foraminifera which it contains.

(b) Sample from between 265 and 295 ft., King Edward Street Bore, Perth.

In containing the species *Gonyaulax edwardsi, Hystrichosphaeridium siphoniphorum, Cyclonephelium compactum, Ceratocystidiopsis ludbrooki, Odontochitina operculata* and *Chlamydophorella nyei*, this deposit is closely linked with the lower part of the Gearle Siltstone, especially the sample from Well No. 7 between 2360 and 2375 ft., and is therefore almost certainly of Albian age.

(c) Deposit from Subiaco bore, W.A., at 358 ft.

The age of this deposit has been discussed earlier when the suggestion was made that it could be either Upper Albian or Lower Cenomanian. The occurrence in it of *Ceratocystidiopsis ludbrooki* suggests an Albian age while the presence of *Deflandrea acuminata* supports a Cenomanian age.

(3) Deposit from 230 ft., Seismic shot hole B.2, near Gingin.

This sample seems to have been a mixed one, but portion of it contains a microplankton assemblage approximating to that of the Gearle Siltstone (lower part) and the deposit from the King Edward Street Bore, more particularly to the latter in containing *Palaeohystrichophora dispersa* which has been found in only these two deposits. The age of this sample therefore appears to be Albian.

(4) Deposit from Wapet's Moora bore between 86 and 170 ft.

From the occurrence of *Pseudoceratium turneri* in association with such types as *Gonyaulax edwardsi, Palaeohystrichophora multispina, Cyclonephelium compactum* and *Odontochitina operculata*, all of which this sample holds in common

with the Albian deposit from Rough Range Well No. 1 at 2750 ft., it is estimated that the age of the Moora bore sample between 86 and 170 feet is Albian.

B. *Palaeontological*

One of the most striking features of the microplankton assemblages contained in the Upper Mesozoic deposits of Western Australia and Papua, is the great variety of types and the large number of new species included in them. This richness in new types may of course be only apparent, and when more work on microplankton has been published, some of these forms may prove to have a much wider distribution.

The relatively large number of Australian species of the genus *Deflandrea* is noteworthy in contrast to the single European species *D. phosphoritica* from the Lower Tertiary of Germany and Belgium. Previously five Tertiary (Deflandre and Cookson, 1955) and one upper Cretaceous species (Cookson, 1956) had been described from Australian deposits. Now six more have been distinguished making twelve in all, and the time range of the genus has been extended to Lower Cretaceous (Upper Neocomian or Lower Aptian).

The genus *Gonyaulax* is also strongly represented, the number of species described in this paper being by no means a complete representation of the forms present. This is particularly so with the Papuan types, which, with the exception of *Gonyaulax perforans*, and *Gonyaulax serrata* have been too imperfectly preserved for description.

The occurrence of *Wetzeliella irregularis* in the Upper Jurassic of Cape Range marks the first Mesozoic record of the genus *Wetzeliella*. Hitherto it has been recorded from Tertiary deposits only.

Acknowledgements

We wish to express our indebtedness to Mr. J. N. Montgomery, Australasian Petroleum Company Ltd., Dr. Nell Ludbrook, South Australian Department of Mines, and Mr. F. S. Colliver, University of Queensland, for geological samples, and to Dr. Ross McWhae, West Australian Petroleum Pty. Ltd., for valuable information regarding the location and stratigraphical position of the Western Australian sediments.

We also extend thanks to Dr. G. Baker, Mineragraphic Section, C.S.I.R.O., for his help with the preparation of the typescript of this paper, and to Professor T. Braarud, of Oslo University, for his interest in this work. One of us (I.C.C.) has received considerable financial assistance from the Commonwaelth Scientific and Industrial Research Organization and travel grants from the University of Melbourne and the Bureau of Mineral Resources.

TABLE 1

Distribution of some of the components of the microplankton in Australian, New Guinea and European Middle and Upper Jurassic deposits

Species	Middle to base of Upper Jurassic		Upper Jurassic							Kimeridgian
	1	2	3	4	5	6	7	8	9	10
Gymnodinium crystallinum ..	+	+	+	−	+	−	+	+	−	−
Gymnodinium luridum	−	−	+	−	+	−	−	+	−	−
Gonyaulax ambigua	−	−	+	?	−	−	+	−	+	+
Gonyaulax jurassica	+	+	+	+	+	−	−	+	+	−
Dingodinium jurassicum ..	−	−	+	−	+	+	−	−	−	−
Nannoceratopsis pellucida ..	−	−	+	−	+	−	+	−	−	−
Cannosphaeropsis aemula ..	−	+	+	−	+	−	+	+	−	−
Cannosphaeropsis filamentosa ..	+	+	+	+	−	−	−	−	−	−
Cannosphaeropsis mirabilis ..	−	−	−	−	−	−	+	−	−	−
Wanaea clathrata	−	−	+	−	−	−	+	−	−	−
Wanaea spectabilis	−	+	−	−	−	+	−	−	−	−
Wanaea digitata	−	−	−	+	+	−	−	−	−	−
Broomea ramosa	+	−	+	−	+	−	+	−	−	−
Broomea simplex	−	−	−	−	−	+	+	−	−	−
Pareodinia aphelia	+	+	+	+	+	−	−	−	−	−

1. Dingo Siltstone, Cape Range Well 1, 6365-83 ft.
2. Dingo Siltstone, Cape Range Well 2, 6032-60 ft.
3. Dingo Siltstone (upper part), Cape Range Well 2, 3970-91 ft.
4. Learmonth formation, Rough Range Well 1, 4376-79 ft.
5. Broome Bore at 1405-37 ft.
6. Omati, Well 1, Samples 36-42.
7. Omati, Well 1, Samples 19-35.
8. Villers, sur/Mer, France (Oxfordian).
9. Kimeridge, England.
10. Orbagnoux, France.

TABLE 2

Distribution of some of the components of the microplankton in Australian and New Guinea Cretaceous deposits

Species	Lower Cretaceous																Upper Cretaceous		
	Neocomian		Aptian						Albian								Cenomanian		Campanian
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Deflandrea acuminata	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−
Deflandrea cincta	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Gonyaulax edwardsi	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	−
Dingodinium cerviculum	+	−	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−
Palaeohystrichophora multispina	−	−	−	−	−	−	−	−	−	+	−	+	−	−	+	−	−	−	−
Palaeohystrichophora dispersa	−	−		−	−	−	−	−	−	−	−	−	−	+	−	+	−	−	−
Muderongia mcwhaei	−	−	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−
Hystrichosphaeridium complex	+	−	−	+	+	−	−	+	+	+	+	+	−	−	+	−	−	−	−
Hystrichosphaeridium recurvatum	−	−	−	−	−	−	−	−	+	+	+	+	−	+	+	−	−	−	+
Hystrichosphaeridium siphoniferum	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	+	−	+	−
Cyclonephelium compactum	−	−	−	−	−	−	−	+	+	+	−	+	+	−	+	+	−	−	−
Pseudoceratium tetracanthum	−	−	−	−	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−
Pseudoceratium turneri	−	−	−	−	−	−	−	+	?	+	+	+	−	−	+	−	−	−	−
Ceratocystidiopsis ludbrooki	−	−	−	−	−	−	−	−	−	+	−	+	−	+	−	+	−	+	−
Odontochitina operculata	−	−	−	−	−	−	−	−	+	+	+	+	−	+	+	+	+	+	−
Fromea amphora	−	−	−	−	−	−	−	+	+	+	−	+	+	+	+	−	−	+	−
Chlamydophorella nyei	−	−	+	−	−	−	−	+	+	+	−	+	+	+	+	+	+	+	−

1. "Wapets' Grierson", Well No. 3, W.A., between 1390–1400 ft.
2. "Grierson Member", Birdrong Formation, Meadow Bore No. 9, W.A.
3. South Perth Formation, Attadale Bore at 809 ft.*
4. Muderong Shale, W.A.
5. Windalia Radiolarite, W.A.
6. Cootabarlow Bore No. 2, S.A., at 1354 ft.
7. Omati, Papua, Samples, No. 9 and 5.
8. Roma Series, Q'land, Batavia Downs Station Well at 45-49 ft.
9. Onepah Well, N.S.W.
10. Cootabarlow Bore No. 2, S.A., at 581 ft.
11. Styx River Series, Q'land, Bore 21 at 327 ft.
12. Gearle Siltstone (lower part), W.A.
13. *Gingin, W.A., shot hole L.8 at 240 feet.
14. *Gingin, W.A., shot hole B.2 at 230 feet.
15. *Moora Bore, W.A., between 86-170 feet.
16. *King Edward Street Bore, W.A., 265-95 ft.
17. Gearle Siltstone (upper part), W.A.
18. *Subiaco Bore, W.A., at 358 ft.
19. Korojon Calcarenite, W.A.

* The age of deposits so marked has been based on the composition of the microplankton and is only approximate.

References

Brunnschweiler, R., 1954. Mesozoic statigraphy and history of the Canning Desert and Fitzroy Valley, Western Australia. *J. Geol. Soc. Aust.*, 1; 1953.

Cookson, Isabel C., 1953. Reeords of the oecurrence of *Botryococcus braunii*, *Pediastrum* and the Hystriehosphaeridae in Cainozoic deposits of Vietoria. *Mem. Nat. Mus. Melb.*, 18; 107-23.

———, 1956. Additional microplankton from Australian Late Mesozoic and Tertiary sediments. *Aust. J. Mar. Freshw. Res.*, 7; 183-191.

Deflandre, G., 1936. Mierofossiles des silex crétacés. Première partie-Généralités-Flagellés. *Paléont.*, 25; 3-43.

———, 1937. Microfossiles des silex crétaeés. Deuxième partie-Flagellés Ineertae Sedis Hystriehosphaeridés. Sarcodinés. Organismes divers. *Ann. Paléont.*, 26; 1-55.

———, 1938. Mieroplaneton des mers jurassiques eonservé dans les marnes de Villers-sur-mer (Calvados). Étude liminaire et considérations générales. *Trav. Stat. Zool. Wimereux*, 13; 147-200.

———, 1942. Le mieroplaneton kiméridgien d'Orbagnoux. *Acad. Sci. Inst. France Mém.*, 65; 1-32.

———, 1947. Sur quelques mieroorganismes planktoniques des Silex jurassiques. *Bull. Inst. Océanogr. Monaco*, 44; no. 921; 1-10.

——— and Cookson, Isabel C., 1955. Fossil microplankton from Australian Late Mesozoic and Tertiary sediments. *Aust. J. Mar. Freshw. Res.*, 6; 242-313.

Downie, C., 1957. Mieroplankton from the Kimeridge Clay. *Q.J.G.S.*, 112; 413-433.

Eisenack, A., 1934. Neue Mikrofossilien des baltisehen Silurs III, und neue Mikrofossilien des böhmisehen Silurs I. *Palaeontolog. Z.*, 16; 52-76.

———, 1954. Mikrofossilien aus Phosphoriten des samländischen Unteroligozäns und über die Einheitlichkeit der Hystriehosphaerideen. *Palaeontographica A*, 105; 49-95.

Gocht, H., 1957. Mikroplankton aus dem nordwestdeutschen Neokom (Teil I). *Paläont Z.*, 31; 163-185.

Lejeune-Carpentier, Maria, 1941. Sur *Hystrichosphaeridium hirsutum* (Ehrenberg) et quelques formes voisines. *Ann. Soc. Géol. de Belg.*, 64; 71-92.

McWhae, J. R. H., Playford, P. E., Lindner, A. W., Glenister, B. F., and Balme, B. E., 1957. The stratriography of Western Australia. *J. Geol. Soc. Aust.* (manuseript).

Parr, W. J., 1938. Upper Eoeene foraminifera from deep borings in King's Park, Perth, Western Australia. *J. Roy. Soc. W.A.*, 24; 69-101.

Schiller, J., 1937. Dinoflagellatae in Rabenhorst's Kryptogamen-Flora. Bd. 10, Abt. 3, Teil 2, p. 476.

Teichert, C., 1941. Marine Jurassic of East Indian affinities at Broome, north-western Australia. *J. Roy. Soc. W.A.*, 26; 1940, 103-119.

———, 1947. Statigraphy of Western Australia. *Bull. Amer. Assoc. Pet. Geol.*, 31; 1-7.

Valensi, L., 1953. Microfossiles des Silex du Jurassique Moyen. *Mem. Soc. Géol. France*, 68; 1-100.

Walkom, A. B., 1919. Mesozoic Floras of Queensland Parts III and IV. *Queensland Geol. Surv. Pub.*, No. 263.

Explanation of Plates

All photographs are from untouehed negatives.

Registered numbers in the palaeobotaniea1 eollection of the National Museum of Victoria are given.

Plate I

Fig. 1.—*Gymnodinium crystallinum* Defl. Broome, Artesian Bore No. 3, W.A., 1405-27 ft. × 550. P 17232.

Fig. 2.—*Gymnodinium crystallinum*. Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. × 300. P 17233.

Fig. 3.—*Gymnodinium luridum* Defl. Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1, 3825-40 ft. × *c.* 400. P 17234.

Fig. 4.—*Gymnodinium luridum*. Dingo Siltstone, W.A., Wapet's Cape Range Well No. 1, 3825-40 ft. × *c.* 370. P 17235.

Fig. 5.—*Gymnodinium crystallinum* sp. nov. Dingo Silstone (middle), W.A., Wapet's Cape Range Well No. 1, 6365-83 ft. × *c.* 350. P 17236.

Fig. 6.—*Gymnodinium parvimarginatum* sp. nov. Holotype, Broome, Artesian Bore No. 3, W.A., 1405-27 ft. × 400. P 17237.
Fig. 7.—*Gymnodinium attadalense* sp. nov. Holotype, South Perth Formation, W.A., Attadale Artesian Bore at 809 ft. × 400. P 17238.
Fig. 8.—*Gymnodinium nelsonense* Cookson. Korojon Calcarenite, Wapet's Rough Range Well No. 4, 1380-88 ft. × *c.* 550. P 17239.
Fig. 9.—*Gymnodinium westralium* sp. nov. Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, 1380-88 ft. × *c.* 580. P 17240.
Fig. 10.—*Dingodinium jurassicum* sp. nov. Holotype, Broome Artesian Bore No. 3, W.A., 1405-27 ft. × *c.* 550. P 17241.
Fig. 11.—*Dingodinium jurassicum*. Sideview of a Paratype. Dingo Siltstone W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. × *c.* 560. P 17242.
Fig. 12.—*Dingodinium cerviculum* sp. nov. South Perth Formation, W.A., Attadale Artesian Bore at 700 ft. × 400. P 17243.
Figs. 13, 14.—*Dingodinium cerviculum*. Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Artesian Bore No. 9 Fig. 13 × c. 350. P 17267. Fig. 14, holotype × *c.* 450. P 17244.

Plate II

Fig. 1.—*Gonyaulax perforans* sp. nov. Holotype, Omati, Papua, I.E.C. Well No. 1, Sample 31 × *c.* 300. P 17256.
Fig. 2.—*Gonyaulax perforans*. Omati, Papua, Well 1, Sample 31 × *c.* 300. P 17257.
Figs. 3, 4.—*Gonyaulax perforans*. Two highly ornamented specimens. Omati, Papua, Sample 31 Fig. 3, dorsal surface × 350. P. 17258. Fig. 4, ventral surface showing longitudinal furrow × 350. P 17256.
Fig. 5.—*Gonyaulax scotti* sp. nov. Holotype, Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. × *c.* 300. P 17260.
Fig. 6.—*Gonyaulax scotti*. Ventral view of a paratype. Dingo Siltstone (upper part), Wapet's Cape Range Well No. 2, 3970-91 ft. × *c.* 270. P 17261.
Fig. 7.—*Gonyaulax perforans*. Hypotheca viewed from below, Omati, Papua, Well 1, Sample 31, × 360. P 17262.
Fig. 8.—*Gonyaulax perforans*. Portion of wall showing perforated external ornament, Omati. Papua, Sample 31, × *c.* 350. P 17263.
Fig. 9.—*Gonyaulax jurassica* Defl. Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 6032-60 ft. × *c.* 380. P 17264.
Fig. 10.—*Gonyaulax jurassica*. Learmonth Formation, Wapet's Rough Range Well No. 1, 4376-79 ft. × *c.* 560. P 17265.
Fig. 11.—*Gonyaulax eisenacki* Defl. sub-species *oligodentata* n.sub.sp. Broome, W.A., Artesian Bore No. 3, 1405-27 ft. × *c.* 530. P 17266.

Plate III

Fig. 1.—*Gonyaulax ambigua* Defl. Dingo Siltstone (upper portion), W.A., Wapet's Cape Rough Range Well No. 2, 3825-40 ft. × *c.* 400. P 17439.
Fig. 2.—*Gonyaulax serrata* sp. nov. Holotype, Omati, Papua, I.E.S. Well 1, Sample 20 (Fig. 2). × *c.* 400. P 17446.
Fig. 3.—*Gonyaulax muderongensis* sp. nov. Holotype, Muderong Shale, W.A., Wapet's Rough Range Well No. 8, 3863-83 ft. × *c.* 340. P 17488.
Fig. 4.—*Gonyaulax muderongensis*. Paratype, Muderong Shale, W.A., Wapet's Rough Range Well No. 8, 3863-83 ft. × *c.* 420. P 17489.
Fig. 5.—*Gonyaulax edwardsi* sp. nov. Paratype, Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 1 at 2000 ft. × *c.* 300. P 17493.
Fig. 6.—*Gonyaulax edwardsi*. Holotype, Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 1 at 2000 ft. × *c.* 350. P 17440.
Fig. 7.—*Gonyaulax apionis*. Cootabarlow, S.A., Bore 2 at 600 ft. × *c.* 400. P 17441.
Fig. 8.—*Gonyaulax* sp. Near Gingin, W.A., Seismic shot hole L.8 at 240 ft. × *c.* 300. P 17442.
Fig. 9.—*Gonyaulax* sp. Gearle Siltstone, W.A., Wapet's Rough Range Well No. 7, 2360-75 ft. × *c.* 270. P 17278.
Fig. 10.—*Palaeoperidinium* cf. *ventriosum* (O. Wetzel). Muderong Shale, W.A., Wapet's Rough Range Well No. 8, 3863-83 ft. × *c.* 300. P 17443.

Figs. 11, 12.—*Gonyaulax hyalodermopsis* sp. nov. Holotype, South Perth Formation, W.A., Attadale Bore at 809 ft. Fig. 11, ventral view. Fig. 12, Dorsal view, × *c.* 400. P 17434.

Figs. 13, 14.—*Gonyaulax diaphanis* sp. nov. Holotype, South Perth Formation, Attadale Bore at 999 ft. Fig. 13, ventral view, × *c.* 270. Fig. 14, Dorsal view, × *c.* 300. P 17437.

Plate IV

Figs. 1, 2.—*Deflandrea cincta* sp. nov. Paratypes, probably "Grierson Member" of Birdrong Formation, W.A., Meadow Station, Bore No. 9. Fig. 1, × *c.* 400. P 17255. Fig. 2, × *c.* 450. P 17245.

Fig. 3.—*Deflandrea cincta.* Holotype, Meadow Station, Bore No. 9. × *c.* 400. P 17246.

Fig. 4.—*Deflandrea serratula* sp. nov. Holotype, Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 5 at 1570 ft. × *c.* 580. P 17247.

Fig. 5.—*Deflandrea acuminata* sp. nov. Holotype, Gearle Formation (upper portion), W.A., Wapet's Rough Range Well No. 5 at 1570 ft. × *c.* 580. P 17248.

Fig. 6.—*Deflandrea acuminata.* Internal capsule with portion of outer membrane, Wapet's Rough Range Well No. 5 at 1570 ft. × *c.* 550. P 17249.

Figs. 7, 8.—*Deflandrea acuminata.* Fig. 7, Rough Range Well No. 5 at 1570 ft. × *c.* 400. P 17250. Fig. 8, Subiaco, W.A., Water Bore No. 8 at 358 ft. × *c.* 600. P 17251.

Fig. 9.—*Deflandrea pellucida* sp. nov. Holotype, Nelson Bore, Vic., at 3874 ft. × *c.* 428. P 16237.

Fig. 10.—*Deflandrea korojonensis* sp. nov. Holotype, Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, 1380-88 ft. × *c.* 600. P 17252.

Fig. 11.—*Deflandrea korojonensis.* Paratype, Wapet's Rough Range Well No. 4, 1380-88 ft. × *c.* 325. P 17253.

Fig. 12.—*Deflandrea parva* sp. nov. Holotype, Gingin, W.A., Seismic shot hole B.1 at 230 ft. × *c.* 525. P 17254.

Fig. 13.—*Deflandrea parva.* Paratype, Gingin, Seismic shot hole B.1 at 230 ft. × *c.* 400. P 17254.

Plate V

Fig. 1.—*Pseudoceratium tetracanthum* Gocht. Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 7, 3532-50 ft. × *c.* 300. P 17268.

Figs. 2, 4.—*Pseudoceratium turneri* sp. nov. Paratype, Omati, Papua, I.E.C. Well No. 1, Sample 4. Fig. 2, × *c.* 330. P 17269. Fig. 4, × *c.* 320. P 17271.

Fig. 3.—*Pseudoceratium turneri.* Holotype, Gearle Siltstone, W.A., Rough Range No. 1 at 2750 ft. × *c.* 420. P 17270.

Fig. 5.—*Pseudoceratium turneri.* Paratype, Roma Series, North Queensland Well on Batavia Downs Station, 45-49 ft. × *c.* 300. P 17272.

Fig. 6.—*Pseudoceratium turneri.* A detached apical horn, Gearle Siltstone, W.A., Rough Range No. 1 at 2750 ft. × *c.* 350. P 17270.

Fig. 7.—*Ceratocystidiopsis ludbrooki* sp. nov. Holotype, Cootabarlow, S.A., Bore at 581 ft. × *c.* 300. P 17273.

Fig. 8.—*Ceratocystidiopsis ludbrooki.* Paratype, Gearle Siltstone (lower part), W.A. Wapet's Rough Range Well No. 7, 2360-75 ft. × *c.* 300. P 17274.

Fig. 9.—*Hystrichodinium amphiacanthum* sp. nov. Omati, Papua, I.E.C. Well 1, Sample 19. × *c.* 300. P 17275.

Figs. 10, 11.—*Fromea amphora* sp. nov. Fig. 10, Holotype, Cootabarlow, S.A., Bore 2 at 581 ft. × *c.* 380. P 17276. Fig. 11, Paratype, Gingin, W.A., Seismic shot hole L.8 at 240 ft. × *c.* 420. P 17277.

Plate VI

Fig. 1.—*Muderongia mcwhaei* sp. nov. Paratype, Muderong shale, W.A., Wapet's Rough Range Well No. 8, 3863-81 ft. × *c.* 300. P 17278.

Fig. 2.—*Muderongia mcwhaei.* Holotype, Cootabarlow, S.A., Bore 2 at 1354 ft. × *c.* 320. P 17279.

Figs. 3, 4, 5.—*Muderongia mcwhaei.* Paratypes showing "girdle". Fig. 3, Muderong shale, W.A., × *c.* 400. P 17280. Fig. 4, Muderong shale, W.A., × *c.* 350. Fig. 5, South Perth Formation, W.A., Attadale Artesian Bore at 809 ft. × *c.* 560. P 17282.

Fig. 6.—*Broomea ramosa* sp. nov. Antapical region of a Paratype showing the longitudinal subdivision of the antapical horns, Broome, W.A., Artesian Bore No. 3, 1405-27 ft. × *c.* 400. P 17283.

Figs. 7, 8.—*Broomea ramosa*. Fig. 7, Holotype, Broome, W.A., Artesian Bore No. 3, 1405-27 ft. × *c*. 300. P 17284. Fig. 8, Paratype focused to show "girdle", Broome Artesian Bore No. 3, 1405-27 ft. × *c*. 350. P 17285.

Fig. 9.—*Broomea simplex*. Holotype, Omati, Papua, I.E.C. Well No. 1, Sample 24 (Table 1). × *c*. 200. P 17286.

Figs. 10, 11.—*Pyxidiella pandora* sp. nov. Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. Fig. 10, Holotype, × *c*. 600. P 17287. Fig. 11, Paratype, × *c*. 600. P 17288.

Plate VII

Fig. 1.—*Cannosphaeropsis fenestrata* Defl. and Cookson. Windalia Radiolarite, W.A., Wapet's Rough Range Well No. 4, 3532-50 ft. × *c*. 390. P 17259.

Figs. 2, 3.—*Cannosphaeropsis fenestrata*. Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7, 2360-75 ft. Fig. 2 × *c*. 300. P 17278. Fig. 3 × *c*. 350. P 17492.

Fig. 4.—*Cannosphaeropsis utinensis filifera* sub-sp. nov. Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, 1380-88 ft. × *c*. 400. P. 17280.

Fig. 5.—*Cannosphaeropsis acmula* Defl. Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. × 300. P 17281.

Figs. 6, 7.—*Cannosphaeropsis acmula* sub. sp. *integra* sub-sp. nov. Dingo Siltstone (middle part), W.A., Wapet's Cape Range Well No. 1, 6365-83 ft. Fig. 6 × 420. P 17490. Fig. 7 × 400. P 17445.

Figs. 8, 9.—*Cannosphaeropsis filamentosa* sp. nov. Fig. 8, Paratype, Dingo Siltstone (upper part), Wapet's Cape Range Well No. 2, 6030-60 ft. × *c*. 430. P 17444. Fig. 9, Holotype, Learmonth Formation, W.A., Wapet's Rough Range Well No. 1, 4376-79 ft. × *c*. 400. P 17446.

Plate VIII

Fig. 1.—*Cannosphaeropsis filamentosa*. Learmonth Formation, W.A., Wapet's Rough Range Well No. 1, 4376-79 ft. × *c*. 480. P 17438.

Fig. 2.—*Cannosphaeropsis filamentosa*. Dingo Siltstone, W.A., Wapet's Cape Range Well No. 2, 6032-60 ft. × *c*. 400. P 17447.

Figs. 3, 5.—*Cannosphaeropsis mirabilis* sp. nov. Omati, Papua, I.E.C. Well 1, Sample 19 (Fig. 2). Fig. 3, Holotype, × *c*. 400. P 17448. Fig. 5, Paratype showing linear arrangement of processes, × *c*. 400. P 17450.

Fig. 4.—*Cannosphaeropsis mirabilis*. Omati, Papua, Well 1, Sample 20 (Fig. 2). × *c*. 600. P 17449.

Fig. 6.—*Omatia pisciformis* sp. nov. Omati, Papua, Well 1, Sample 20 (Fig. 2), Holotype, × *c*. 300. P 17451.

Figs. 7, 8.—*Omati montgomeryi* sp. nov. Omati, Papua, Well 1, Sample 19 (Fig. 2). Fig. 7, A Paratype × *c*. 400. P 17452. Fig. 8, Holotype × *c*. 400. P 17453.

Fig. 9.—*Omatia montgomeryi*. Omati, Papua, Well 1, Sample 20 (Fig. 2). × *c*. 600.

Figs. 10, 12.—*Hystrichosphaeridium parvispinum* sp. nov. Omati, Papua, I.E.C. Well 1, Sample 5 (Fig. 2), Paratypes. Fig. 10, × *c*. 600. P 17481. Figs. 11, 12, × *c*. 400. P 17454, P 17455.

Plate IX

Fig. 1.—*Wanaea spectabilis* Defl. and Cookson. Paratype, Omati, Papua, I.E.C. Well 1, Sample 40 (Fig. 2). × *c*. 400. P 17297.

Fig. 2.—*Wanaea digitata* sp. nov. Holotype, Learmonth Formation, W.A., Wapet's Rough Range Well No. 1, 4376-79 ft. × *c*. 280. P 17298.

Figs. 3–5.—*Wanaea digitata*. Paratype, Broome, W.A., Artesian Bore No. 3, 1405-27 ft. Fig. 3, × *c*. 280. P 17299 Figs. 4, 5, × *c*. 400.

Fig. 6.—*Wanaea clathrata* sp. nov. Holotype, Dingo Siltstone (upper part), Wapet's Cape Range Well No. 2, 3970-91 ft. × 300. P 17230.

Figs. 7, 8.—*Wanaea clathrata*. Paratypes, Dingo Siltstone (upper part), Wapet's Cape Range Well No. 2, 3970-91 ft. Fig. 7 × *c*. 280. P 17301. Fig. 8 × *c*. 300. P 17302.

Figs. 9 and 13.—*Pterospermopsis curypteris* sp. nov. Fig. 9, Paratypes, South Perth Formation, W.A., Attadale Bore at 809 ft. × *c*. 280. P 17303. Fig. 13, Holotype, Cootabarlow, S.A., Bore 2 at 1354 ft. × *c*. 300. P 17304.

Figs. 10–11.—*Pterospermopsis aureolata* sp. nov. Probably "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore No. 9. Fig. 10, Paratype × *c*. 300. P 17305. Fig. 11, Holotype × *c*. 300. P 17306.

Fig. 12.—*Pterospermopsis aureolata*. Roma Series, North Queensland, Well on Batavia Downs Station, 45149 ft. × *c*. 300. P 17456.
Fig. 14.—*Cymatiosphaera stigmata*. "Grierson Member", Birdrong Formation, W.A., Meadow Station Bore 9. Holotype × *c*. 400. P 17435.

Plate X

Figs. 1, 2.—*Wetzeliella irregularis* sp. nov. Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. Fig. 1, Holotype × *c*. 470. P 17301. Fig. 2, Paratype × *c*. 430. P 17436.
Figs. 3, 4.—*Leiofusa jurassica* sp. nov. Dingo Siltstone (upper part), Wapet's Cape Range Well No. 1, 3825-40 ft. and Well No. 2, 3970-91 ft. Fig. 3 × *c*. 570. P 17457. Fig. 4, Holotype × *c*. 800. P 17485.
Figs. 5, 6.—*Nannoceratopsis pellucida* Defl. Fig. 5, Dingo Siltstone (upper part), Wapet's Cape Range Well No. 2, 3970-91 ft. × c. 560. P 17458. Fig. 6, Omati, Papua, I.E.C. Well 1, Sample 31 (Fig. 2) × *c*. 420. P 17263.
Figs. 7, 9.—*Membranilarnax leptoderma* sp. nov. Omati, Papua, I.E.C. Well 1, Sample 2 × c. 420. Fig. 7, P 17460. Fig. 9, P 17461.
Fig. 8.—*Membranilarnax* sp. Omati, Papua, Well 6, Sample 2, × *c*. 420. P 17460.
Fig. 10.—*Palaeohystrichophora infusorioides* Defl. Gearle Siltstone (upper part), W.A., Wapet's Rough Range Well No. 8, 1530-48 ft. × 500. P 17462.
Fig. 11.—*Palaeohystrichophora pellifera* sp. nov. Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 1, at 2000 ft. × 550. P 17459.
Fig. 12.—*Palaeohystrichophora dispersa* sp. nov. Near Gingin, W.A., Seismic shot hole B.2 at 230 ft. × 630. P 17463.
Fig. 13.—*Palaeohystrichophora multispina* Defl. and Cookson. Gearle Siltstone (lower part) Rough Range Well No. 7, 2360-75 ft. × *c*. 525. P 17492.
Fig. 14.—*Palaeohystrichophora dispersa*. Near Gingin, W.A., Seismic shot hole B.2 at 230 ft. × *c*. 400. P 17463.

Plate XI

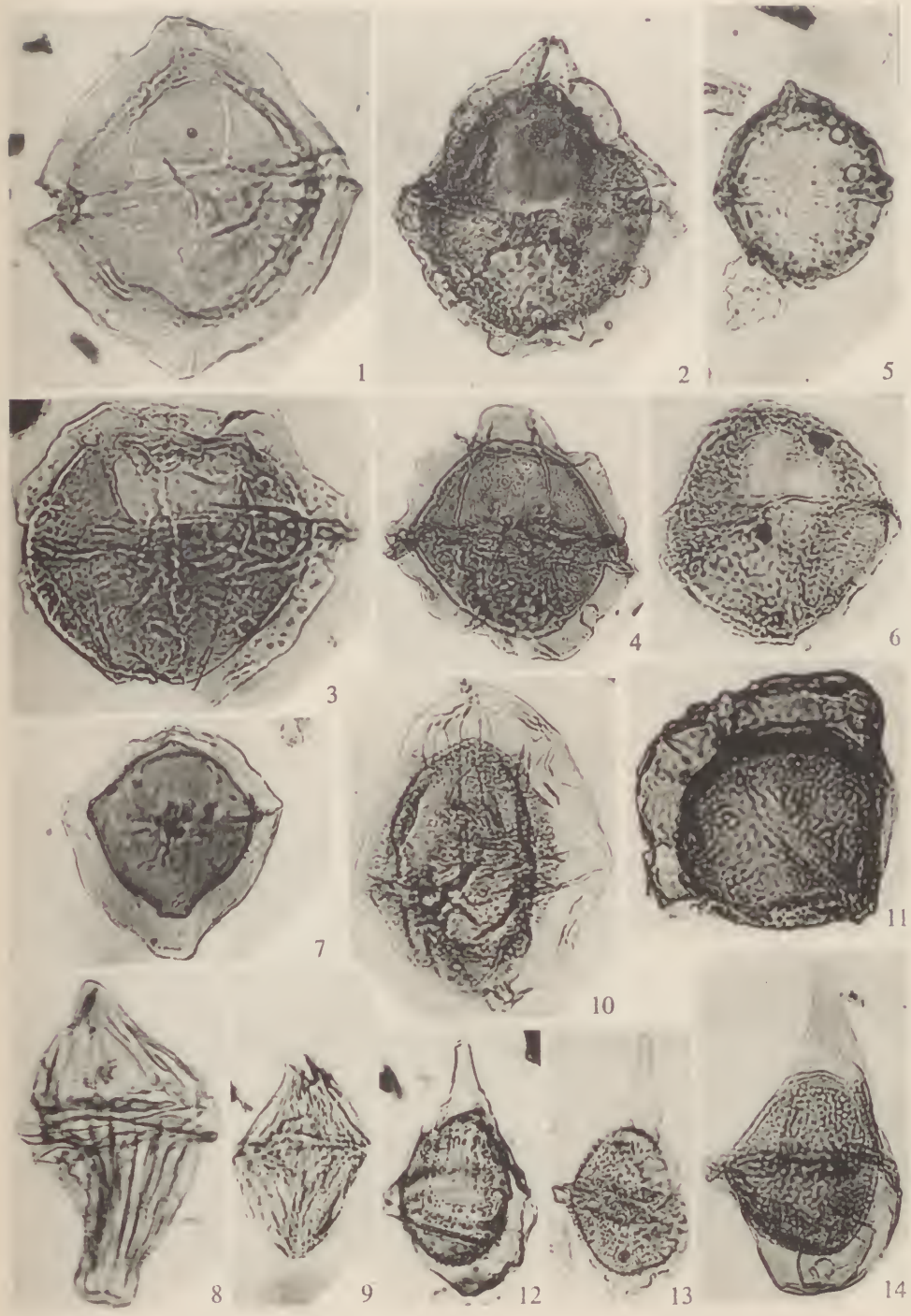
Fig. 1.—*Chlamydophorella nyei*, sp. nov. Holotype, Roma Series, North Queensland, Batavia Downs Station Well, Cape York Peninsula, 45-49 ft. × *c*. 700. P 17464.
Fig. 2.—*Chlamydophorella nyei*. Paratype, Gingin area, W.A., Seismic shot hole L.8 at 240 ft. × *c*. 540. P 17465.
Fig. 3.—*Chlamydophorella nyei*. Polar view, Gearle Siltstone (lower portion), W.A., Wapet's Rough Range Well No. 7, 2360-75 ft. × *c*. 600. P 17491.
Fig. 4.—*Chlamydophorella*? sp. South Perth Formation, W.A., Attadale Bore at 999 ft. × *c*. 500. P 17437.
Figs. 5, 6.—*Hystrichosphaeridium* cf. *hirsutum*. Gearle Siltstone (lower part), Wapet's Rough Range Well No. 7, 2360-75 ft. Fig. 5, × *c*. 400. P 17466. Fig. 6, × *c*. 600. P 17467.
Fig. 7.—*Cymatiosphaera pterota* sp. nov. Holotype, Gingin area, W.A., Seismic shot hole B.2 at 230 ft. × *c*. 530. P 17254.
Figs. 8, 10.—*Hystrichosphaeridium siphoniphorum* sp. nov. Gingin area, W.A., Seismic shot hole B.2 at 230 ft. Fig. 8, Holotype × *c*. 400. P 17468. Fig. 10, Paratype × *c*. 400. P 17469.
Fig. 9.—*Hystrichosphaeridium siphoniphorum*. Paratype showing "lid" of pylome partially open, Subiaco, W.A., Artesian Bore at 358 ft. × *c*. 435. P 17470.
Fig. 11.—*Dioxya armata* sp. nov. Holotype, Omati, Papua, I.E.C. Well 1. Sample 2 × *c*. 600. P 17461.
Fig. 12.—*Hystrichosphaeridium anthophorum* sp. nov. Holotype, Omati, Papua, I.E.C. Well 1, Sample 5 × *c*. 275. P 17471.
Fig. 13.—*Hystrichosphaeridium anthophorum* sp. nov. Omati, Papua, I.E.C. Well 1, Sample 27 × *c*. 460. P 17473.

Plate XII

Fig. 1.—*Cyclodictyon paradoxos* sp. nov. Holotype, Gearle Siltstone (upper part), Wapet's Rough Range Well No. 5 at 1570 ft. × *c*. 400. P 17474.
Fig. 2.—*Cyclodictyon paradoxos*. Paratype, Gearle Siltstone (lower part), Wapet's Rough Range Well No. 8, 1530-48 ft. × *c*. 400. P 17475.
Fig. 3.—*Pareodinia aphelia* sp. nov. Paratype, South Perth Formation, W.A., Attadale Bore at 809 ft. × *c*. 400. P 17476.
Fig. 4.—*Pareodinia aphelia*. Holotype, Learmonth Formation, W.A., Wapet's Rough Range Well No. 1, 4376-79 ft. × *c*. 400. P 17477.

Fig. 5.—*Coronifera oceanica* sp. nov. Gearle Siltstone (lower part), Wapet's Rough Range Well No. 7, 2360-78 ft. × *c.* 340. P 17479.
Fig. 6.—*Coronifera oceanica*. Holotype, Gearle Siltstone (lower part), Wapet's Rough Range Well No. 7, 2360-78 ft. × *c.* 400. P 17478.
Fig. 7.—*Cyclonephelium compactum* Defl. and Cookson. Cootabarlow, S.A., Bore No. 2 at 581 ft. × *c.* 440. P 17273.
Fig. 8.—*Cyclonephelium compactum*. Gearle Siltstone (lower part), W.A., Wapet's Rough Range Well No. 7, 2360-75 ft. × *c.* 400. P 17480.
Fig. 9.—*Parcodinia aphelia* sp. nov. Dingo Siltstone (upper part), W.A., Wapet's Cape Range Well No. 2, 3970-91 ft. × *c.* 500. P 17481.
Fig. 10.—*Hystrichosphaeridium complex* (White). Muderong Shale, W.A., Wapet's Rough Range Wall No. 8, 3863-81 ft. × *c.* 425. P 17487.
Figs. 11, 12.—*Palaeohystrichophora isodiametrica* sp. nov. Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, 1380-88 ft. Fig. 11, a Paratype × *c.* 470. P 17482. Fig. 12, Holotype × *c.* 430. P 17483.
Fig. 13.—*Korojonia dubiosa* sp. nov. Korojon Calcarenite, W.A., Wapet's Rough Range Well No. 4, 1380-88 ft. × *c.* 420. P 17486

List of Species


1
2
5
3
4
6
7
10
11
8
9
12
13
14